DISCONTINUED PRODUCT

AC Power
For *Business-Critical Continuity™*

Liebert® FS™ DC Energy Storage System

User Manual - 200kW/12 Seconds, 540VDC

EMERSON
Network Power

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FIGURES

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SAVE THESE INSTRUCTIONS

This manual contains important instructions that should be followed during installation and maintenance of your Liebert FS.

WARNING

The installation of the Liebert FS must comply with applicable national, federal, state and local codes.

ONLY qualified service personnel should perform maintenance on the Liebert FS system. When performing maintenance with any part of the equipment, service personnel and test equipment should be standing on rubber mats. The service personnel should wear insulating shoes for isolation from direct contact with the floor (earth ground).

Never work alone, even if all power is removed from the equipment. A second person should be standing by to assist and summon help in case an accident should occur.

Under typical operation and with all UPS doors closed, only normal safety precautions are necessary. The area around the Liebert FS system should be kept free of puddles of water, excess moisture and debris.

Special safety precautions are required for procedures involving handling, installation and maintenance of the UPS system. Observe all safety precautions in this manual before handling, installing or operating the UPS system.

This equipment contains circuits that are energized with high voltage. Only test equipment designed for troubleshooting and for use with those voltages should be used. Always check with an AC and DC voltmeter to ensure safety before making contact or using tools. Even when the power is turned Off, dangerously high electric charges may exist within the UPS.

WARNING

Exercise extreme care when handling Liebert FS cabinets to avoid equipment damage or injury to personnel. Refer to **Section 3.0** and **Section 4.0** for equipment handling information and installation procedures.

In case of fire involving electrical equipment, use only carbon dioxide fire extinguishers or others approved for use in fighting electrical fires.

WARNING

Extreme caution is required when performing maintenance.

Be constantly aware that the Liebert FS contains high DC as well as AC voltages. With input power off and the battery disconnected, high voltage at filter capacitors and power circuits should be discharged within 30 seconds. However, if a power circuit failure has occurred, you should assume that high voltage may still exist after shutdown. Check with a voltmeter before making contact.

Check for voltage with both AC and DC voltmeters prior to making contact.

WARNING

When the Liebert FS is under power, both the operator and any test equipment must be isolated from direct contact with earth ground and the Liebert FS chassis frame by using rubber mats.

Some components within the cabinets are not connected to chassis ground. Any contact between floating circuits and the chassis is a lethal shock hazard. Exercise caution that the test instrument exterior does not make contact either physically or electrically with earth ground.

CAUTION

Do not loosen or tamper with vacuum components and fittings.

CAUTION

This unit contains components sensitive to electrostatic discharge.

CAUTION

Do not remove plug-in printed circuit cards during operation. Improper removal of a card can cause severe damage to the unit.

CAUTION

The 110/230VAC must remain connected at all times to ensure reliable backup power to Liebert FS auxiliaries.

CAUTION

Do not use this unit for other than its intended use.

CAUTION

A qualified electrician must perform all electrical connections.

All wiring size and installation must comply with all applicable local, regional and national regulations (e.g., National Electric Code for USA).

Safety Precautions

Read this manual thoroughly, paying special attention to the sections that apply to you, before working with the Liebert FS.

Under typical operation and with all cabinet doors closed, only normal safety precautions are necessary. The area around the Liebert FS should be kept free from puddles of water, excess moisture or debris.

Special safety precautions are required for procedures involving handling, installation and maintenance of the Liebert FS. Observe precautions in **7.0 - Maintenance** before as well as during performance of any maintenance procedure on the Liebert FS.

This equipment contains circuitry that is energized with high voltage. Only test equipment designated for troubleshooting should be used. This is particularly true for oscilloscopes. Always check with an AC and DC voltmeter to ensure safety before making contact or using tools. Even when the power is turned Off, dangerously high voltage may exist at the capacitor banks.

ONLY qualified service personnel should perform maintenance on the Liebert FS. When performing maintenance with any part of the equipment under power, service personnel and test equipment should be standing on rubber mats. The service personnel should wear insulating shoes for isolation from direct contact with the floor (earth ground).

One person should never work alone. A second person should be standing by to assist and summon help in case an accident should occur.

1.0 GENERAL SYSTEM INFORMATION

1.1 General Information

1.1.1 Safety Considerations

Read and follow the instructions in this manual before interacting with the system. This document contains important information and instructions for your Liebert FS. All procedures defined in the manual related to unpacking, installing and operating the unit must be followed.

Refer to this manual before contacting Liebert Services for technical assistance.

WARNING

Failure to recognize electrical hazards could prove fatal. Failure to abide by instructions provided herein may void your warranty.

1.1.2 Requesting Assistance from Liebert

If you require assistance for any reason, contact Liebert Services at 1-800-LIEBERT (1-800-543-2378). Have the following information available:

Table 1 System information

Date Purchased	
Date Installed	
Location	
System Model Number	
System Serial Number	
Interconnected UPS Manufacturer	
Interconnected UPS Model	
Software Version; Primary *	
Software Version; Secondary *	
Software Version; Bootloader *	

1.2 General System Description

The Liebert FS is a flywheel energy storage system, a mechanical battery that stores energy in the form of a rotating mass. This energy is immediately convertible to useful electric power.

The Liebert FS is available with a wide performance range up to 200kW as a single unit configuration.

Figure 1 Liebert FS

The Liebert FS is configured as a two-terminal plus ground DC flywheel power system and is used as a functional replacement for or an availability supplement to a bank of chemical batteries for an Uninterruptible Power System. Like a chemical battery bank, Liebert FS receives charge and float power from the two terminal UPS DC bus and returns power to the same DC bus whenever the bus voltage droops below a programmable threshold level.

Integrated into a UPS, the Liebert FS is used as the alternate source of power to supply DC power to the UPS inverter if the AC supply voltage (UPS input) is outside the acceptable range. The Liebert FS supplies power to the UPS inverter until the utility power is restored, until an alternate power source is available, or until the Liebert FS' energy is exhausted.

One or more Liebert FS units may be integrated into UPS and can be put in parallel as shown in **Figures 2** and **3**, to achieve higher power output or higher ride-through duration.

Figure 2 Single Liebert FS unit or multiple Liebert FS units integrated into a UPS system

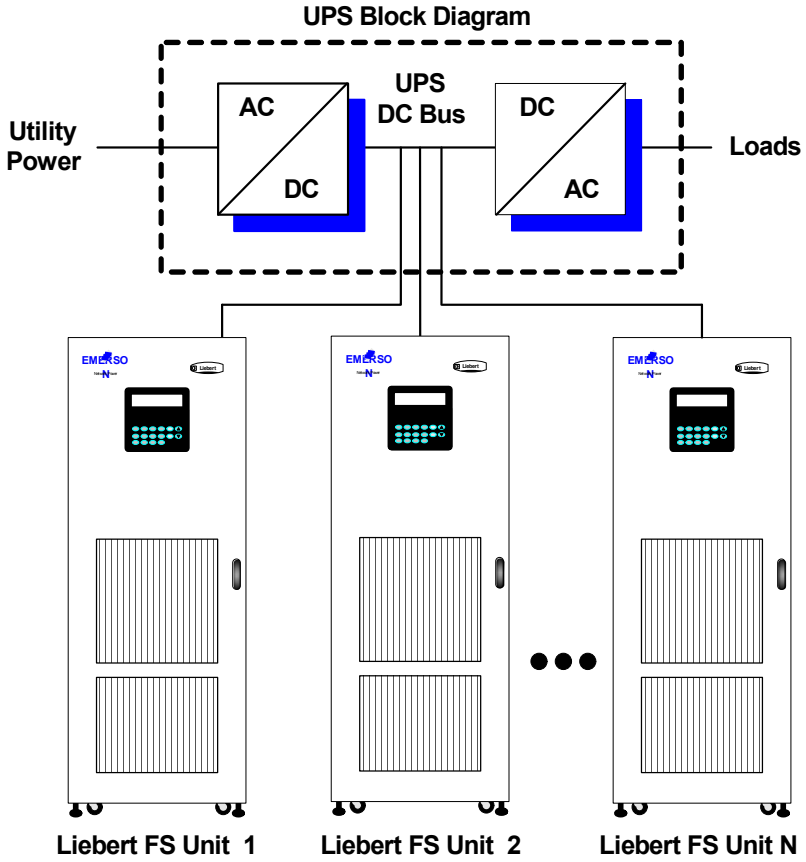


Figure 3 Liebert FS unit(s) integrated into UPS system for ride-through to backup generator

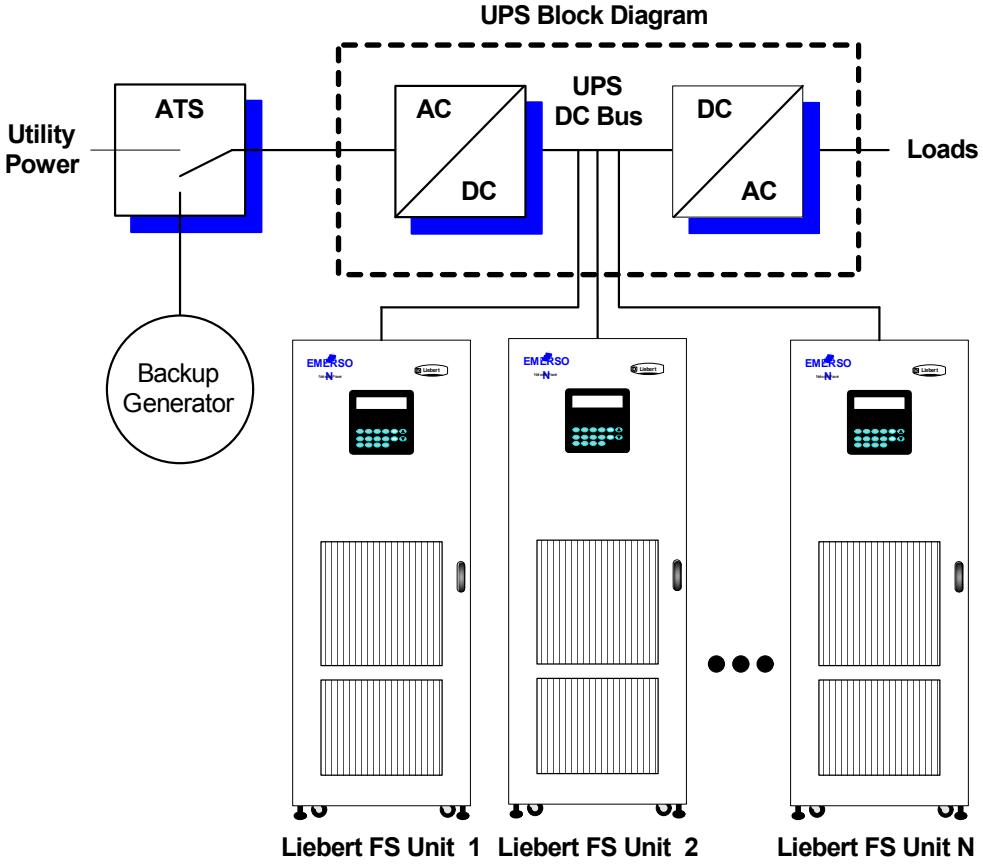
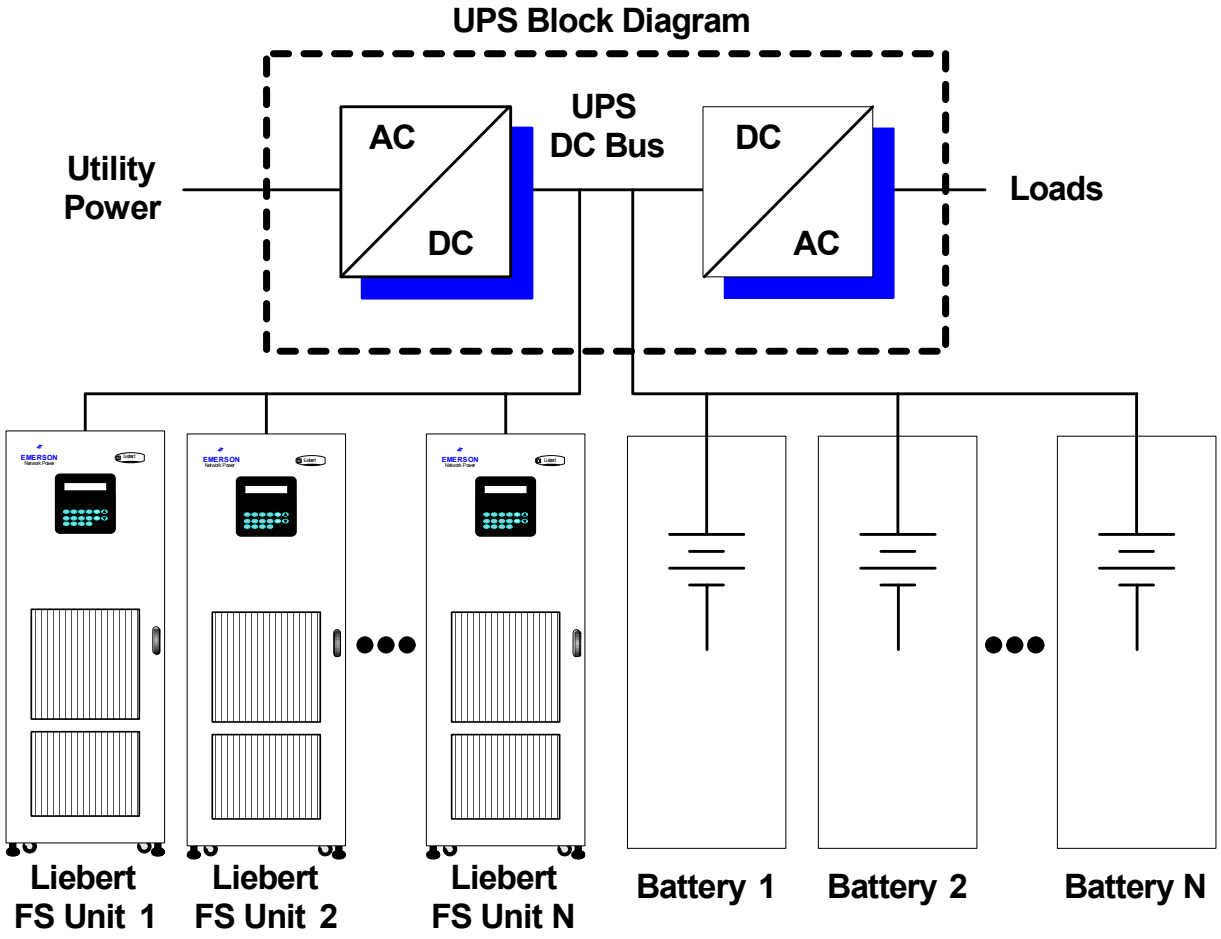


Figure 4 One or more Liebert FS units in parallel with one or more battery strings, battery cabinets or batteries in racks



1.2.1 General Specifications

Table 2 summarizes the technical specifications of the Liebert FS.

Table 2 General system specifications

Rated Power Delivery	Dependent upon the duration required; refer to **Figure 5**
Input Voltage (DC)	360 through 600 VDC; > 530 VDC required for 200kW
Output Voltage (DC)	350 through 590 VDC; > 520 VDC required for 200kW
Input Voltage Aux. (AC)	85 VAC – 265 VAC (47-63Hz)
Operating Temperature	-20°C to 50°C (-4°F to 122°F)
Non-Operating Temperature	-20°C to 80°C (-4°F to 176°F)
Dimensions (W x D x H)	63 x 83 x 180 cm (25 x 33 x 71 in)
Total Weight	590 kg (1,300 lb)

For more-detailed technical specifications, refer to **Technical specifications on page 148**.

1.2.2 Features and Benefits

The Liebert FS provides clean constant DC output to the DC bus, at the user-selected, regulated voltage, until the stored energy is depleted. See **Figure 5** for a graphic representation of the performance power and duration curves of single and paralleled unit combinations.

Key Technological Features

- Active magnetic bearings
- Internal, integrated vacuum system
- Synchronous reluctance motor-generator
- Fiber composite flywheel
- Unique patented safety system

Key Customer Benefits

- High reliability
- Significantly increased power supply reliability
- Low total cost of ownership
- Operational flexibility
- Environmentally friendly
- Easy to install and easy to operate.
- Low standby losses
- Small footprint
- Lightweight
- Reliable, cost effective power systems for UPS ride-through needs

1.2.3 Applicable Standards and Certification

For distribution in North America, the Liebert FS is listed to the following Underwriter's Laboratory (UL) applicable requirements:

- UL 508, Standard for Safety for Electrical Industrial Control Equipment;
- UL 1004, Standard for Safety for Electric Motors;
- UL 1248, Standard for Safety for Engine-Generator Assemblies;

The Liebert FS is designed in accordance with the applicable sections of the requirements published by:

- National Fire Protection Association (NFPA)/National Electric Code (NEC)
- National Electrical Manufacturer's Association (NEMA)
- Occupational Safety & Health Administration (OSHA)

The Liebert FS is also listed to the following Canadian Standards as determined by UL (cUL):

- CSA-C22.2 No. 100-04, "Motors and Generators,"
- CSA-C22.2 No. 14-95, "Industrial Control Equipment,"
  The "Uniform Building Code (UBC) Zone 4" certification requirements.

For distribution in Europe, the Liebert FS is CE-marked and meets the applicable requirements of the following European directives:

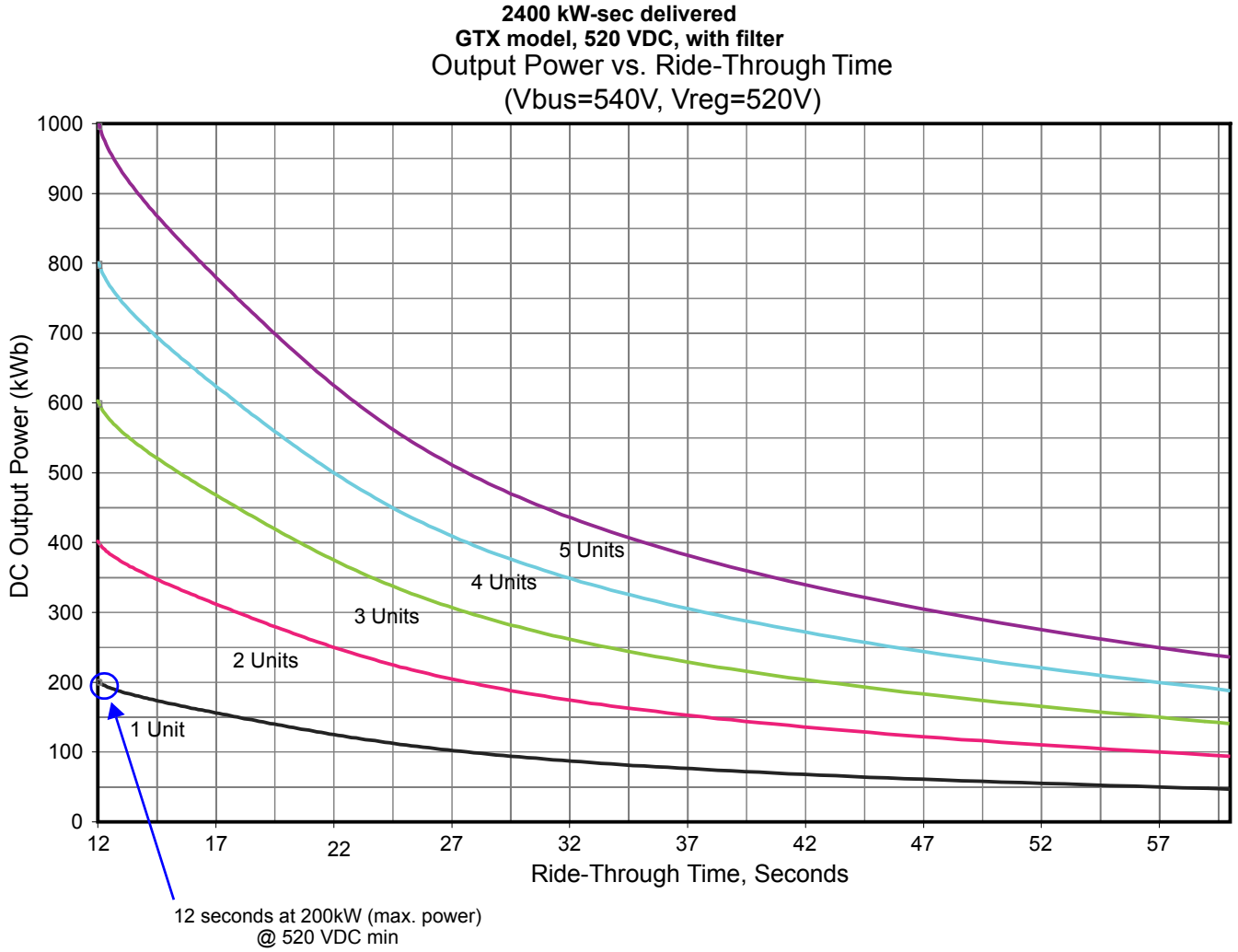
"Low Voltage Directive" 73/23/EEC and its amendments by the directive 93/68/EEC;

"Machinery Directive" 98/037/EEC and its amendments by the directive 98/79/EEC;

- IEC/EN 60439-1:1999—"Low-voltage switchgear and control gear assemblies Part 1: Type-tested and partially type-tested assemblies"
- IEC/EN 60204-1:1997—"Safety of machinery - Electrical equipment of machines Part 1: General requirements"
- EN 1127-1:1997—"Explosive atmospheres: Explosion prevention and protection Part 1: Basic concepts and methodology"
- Machinery Directive Annex 1—"Essential Health and Safety Requirements Relating to the Design and Construction of Machinery and Safety Components"

"Electromagnetic Compatibility (EMC) Directive" 89/336/EEC and its amendments by the directives 92/31/EEC and 93/68/EEC.

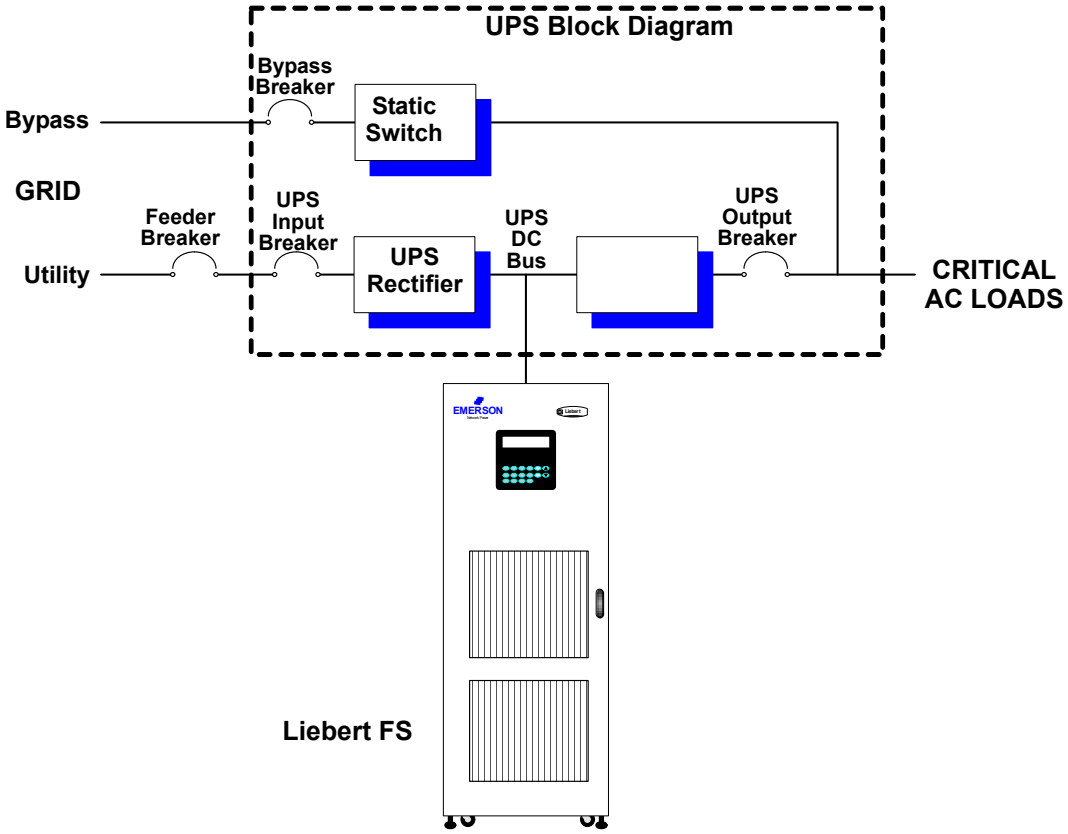
Figure 5 Liebert FS DC power duration for one or multiple units in parallel



kWb = Refers to Kilowatts on the DC bus of the UPS system
Discharge Voltage = 520VDC

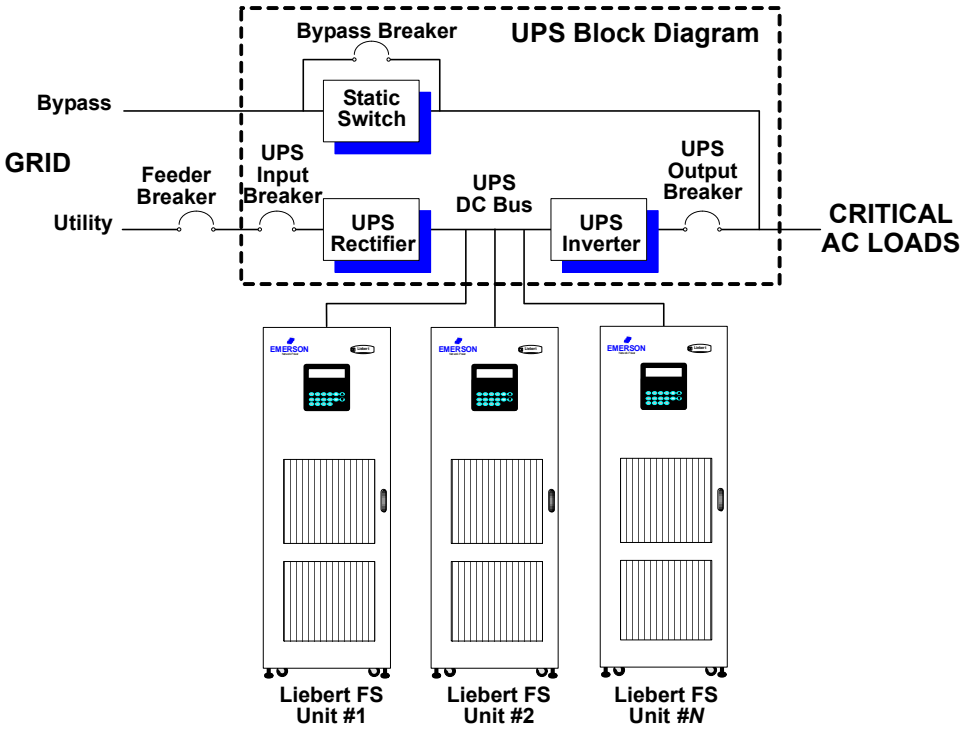
The Liebert FS is integrated into UPS systems as shown in **Figures 2** through **4** and **Figures 6** and **7**.

Figure 6 Integrating a single Liebert FS unit into a UPS system



Several Liebert FS units can be put in parallel to achieve higher power output and higher ride-through duration (see **Figure 7**). One or more Liebert FS units may also be connected in parallel with a UPS battery plant (valve- regulated or wet cells) to provide an overall incremental reliability and life improvement for the DC battery plant. In this situation, the Liebert FS unit would be connected in parallel with the battery plant (through its own disconnect device) to the UPS DC Bus.

Figure 7 Integrating multiple Liebert FS units into a UPS system



2.0 SITE PREPARATION

Site preparation for the Liebert FS is minimal. If a UPS system is already installed, the only requirements are to properly:

- Place the unit in relation to walls, ceiling and other equipment and
- Fasten the unit to the floor.

CAUTION

The following sections should be read thoroughly before proceeding with site preparation for installing the Liebert FS.

NOTE

All drawings referred to in this section are in ***Appendix D.0 - Installation Drawings****.*

2.1 System Location

Choose a location for the Liebert FS that offers:

- Easy connection to inputs, outputs and auxiliary equipment
- Enough space to service the Liebert FS
- Air circulation sufficient to expel heat produced by Liebert FS
- Protection against moisture and excessive humidity (not to exceed 95% non-condensing)
- Protection against excessive dust and other particulate matter
- Compliance with fire prevention regulations and practices
- Operating environment temperature of -4°F to 122°F (-20°C to 50°C)

2.2 Environmental Considerations

Place the system in a clean, dust-free environment. Air must be free to circulate around the cabinet(s). The system pulls air through the front of the Liebert FS and exhausts it out the top for cooling. If the unit must be located in a dusty environment, Liebert recommends installing an optional air filter, which mounts on the lower inside of the Liebert FS door.

Adequate ventilation, including air conditioning if necessary, must be provided to limit heat accumulation. The ambient temperature for the unit must be from -4°F to 122°F (-20°C to 50°C). Avoid placing the unit in direct sunlight or near other heat sources.

There is a 32°F (0°C) minimum ambient temperature requirement for starting up the unit. Once the unit has been running for some time, it will keep itself warm enough in ambient temperatures as low as -4°F (-20°C).

Humidity is not to exceed 95% (non-condensing).

2.3 Flooring Requirements

2.3.1 Floor Loading

The Liebert FS should be mounted on a finished surface, such as concrete, block, brick or wood. The floor must be strong enough to support the equipment load and suitable for installation of an anchoring kit with vertical floor loading properly calculated (assume 2,000 PSI or 140 kg/cm^2 contact load at caster wheels; this includes safety factors).

- When installing on a concrete, masonry or stone floor, use the factory-supplied masonry fasteners (anchors). The fastener manufacturer's allowable shear load (parallel to floor) for these fasteners is 2,030 lb. (9 kN) when mounted in normal-weight concrete (2,000 to 3,000 PSI; 140-210 kg/cm^2) of at least 3 in. (7.6cm) thickness.
- If installing on a floor consisting of a material other than normal-weight concrete as described above, the mounting should be capable of sustaining a shear load (parallel to floor) of at least 1,500 lb. (6.7 kN) for each of the four mounting points.
- If installing on a raised floor that is less than 2 in. (5cm) thick or constructed of a material not appropriate for the masonry fasteners provided or lag screw engagement, mount using through bolts with nuts and large diameter washers as shown in **Figure 155**.

Full details for mounting the cabinet are found in **4.1 - Cabinet Floor Mounting**.

NOTE

The above loads (both the fastener manufacturer load and the minimum mounting load) include the required safety factors.

2.3.2 Floor-Space Occupation

The Liebert FS cabinet requires a floor space of 23" wide by 33" deep (63 x 83cm), resulting in a footprint of 5.7 square feet (0.5m^2).

2.3.3 Clearances

The Liebert FS installation requires a ceiling height of at least 7 ft. (214cm).

The unit occasionally vents air out of the top. Loose ceiling tiles above the unit may be moved by the airflow. Ample clearance to access the cable connection at the top of the unit must also be provided. All system electrical connections are to be routed through the top or side of the cabinet.

A 36" (91cm) clearance is required in the front of the unit for National Electrical Code (NEC) compliance.

Maintenance access to all components is from the front; no side or back access is required for maintenance. Either side of the system cabinet can be placed against walls (assuming minimum distance from edge of floor). Repair may require access to the rear of the unit. In this unlikely instance, the unit may need to be rolled out from its installed location (cabinet is on casters).

2.4 Electrical Considerations

CAUTION

A qualified electrician must perform all electrical connections. The wires (DC power, grounding, optional status/control and auxiliary power supply) that connect the Liebert FS system(s) to the UPS system must be provided by the electrical contractor (standard) or by Liebert as an option. Wire size and installation must comply with all applicable local, regional and national regulations (e.g., National Electric Code for USA).

2.4.1 DC Power Connections

Place the Liebert FS as close as practical to the interconnected UPS. The maximum distance allowed between the UPS and the Liebert FS depends on power levels and the type of DC cables used. Liebert requires sizing DC cables and placing the Liebert FS for a maximum of no more than 2V loop drop (at rated power) between the UPS and the Liebert FS.

The Liebert FS is delivered with the standard UPS interconnection kit for connection of the positive and negative terminals coming from the UPS DC bus or from an external disconnect switch.

For details, see **4.2.2 - DC Power Connections**.

2.4.2 Status/Control Connections

Site preparation for Status/Control connections vary according to the type of UPS interconnection kit provided with your Liebert FS.

Liebert recommends making Status/Control connections on the UPS system side.

For details, refer to **4.2.3 - Status/Control Connections**.

2.4.3 Grounding Connections

A grounding wire must be connected from the Liebert FS to the UPS ground terminal. Identify in advance the location of the grounding terminal on the UPS system. For further details, see **4.2.2 - DC Power Connections**.

2.4.4 AC Power Connections

Plan for the availability of a dedicated 110 or 230VAC, 50 or 60Hz circuit with branch circuit protection as a source for AC auxiliary power supply to the Liebert FS. This AC power must be rated for 500VA and must be located either on the output circuit of the UPS system or on another UPS-protected circuit. A qualified electrical contractor should make arrangements for this connection to be permanent.

The field-supplied AC wire must comply with all applicable local, regional and national regulations (e.g., National Electric Code for USA). An 18 AWG (0.82mm^2) cable is recommended for this connection.

For details, see **4.2.5 - AC Auxiliary Control Power Supply Connections** and **Appendix F.0 - Auxiliary Backup AC Power Supply**.

2.4.5 Remote Monitoring Connections—Optional

If the optional Data Collection Module (DCM) is provided with your Liebert FS system, plan to have communication cables (local network connection, phone line) installed to support the remote notification and/or monitoring options chosen.

For details, see **4.2.6 - Remote Monitoring Connections—Optional**.

3.0 UNLOADING AND UNPACKING

NOTE
All drawings referred to in this section are in ***Appendix D.0 - Installation Drawings****.*

3.1 Inspection Before Removal From the Truck

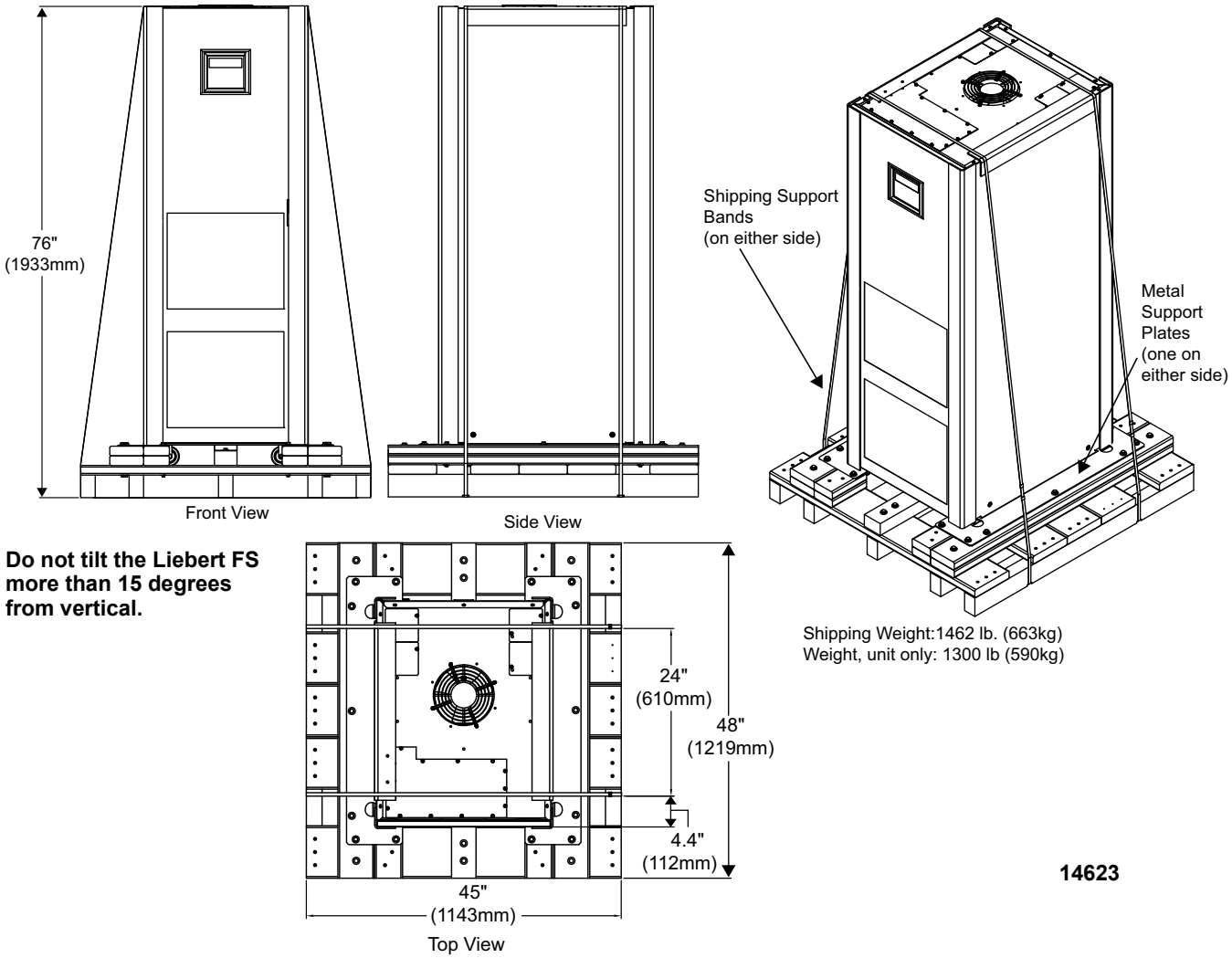
While the Liebert FS shipping package is still on the truck:

- Inspect the equipment and shipping container(s) for any signs of damage or mishandling. Check also if the shock and tilt gauges (installed for shipping purposes) indicate excessive shock and/or tilting. If any damage is noted, file a damage claim with the shipping agency within 24 hours and contact your local sales representative or Liebert at 1-800-LIEBERT to notify them of the damage claim and the condition of the equipment.
- Compare the contents of the shipment with the bill of lading. Report any missing items to the carrier, your local Liebert representative and Liebert at 1-800-LIEBERT immediately. Please have the bill of lading available.

CAUTION
Do not attempt to install the system if damage is apparent.

3.2 Unloading

Figure 8 Liebert FS shipping package



The FS as shipped (see **Figure 8**) can weigh up to 1,462 lb. (663kg). It must be handled with care. It must be kept upright—pay special attention to the arrows, which indicate the upright position.

3.2.1 Handling

The Liebert FS shipping package is designed to be handled using a forklift. Forklift operators must avoid rough handling when picking up, moving and lowering it.

CAUTION
Exhibit care when handling Liebert FS cabinet to avoid equipment damage or injury to personnel. Failure to do so could throw off the calibration of the mechanical components contained in the unit and possibly cause permanent damage.

CAUTION
The Liebert FS has sensitive electronics and mechanical components that have been calibrated prior to shipment.

CAUTION
Test lift and balance the cabinet before transporting it. Maintain minimum tilt from vertical at all times—do not exceed 15 degrees of tilt.

CAUTION
Sheet metal components and framework may have sharp edges.

3.2.2 Unpacking

To reduce the possibility of shipping damage, flywheel cabinets are secured to the pallet by two mounting brackets and two banding straps. These same two mounting brackets are used to mount the cabinet to the floor.

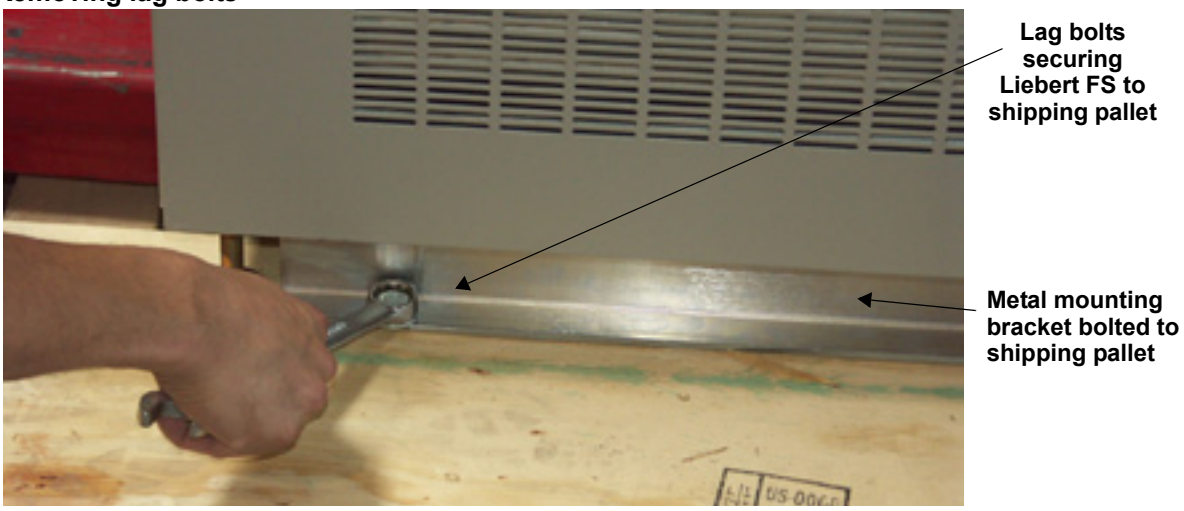
Packing elements should be removed in this order to ease unpacking:

1. Cut and remove the banding straps (see **Figure 8**).

CAUTION
Use care when removing banding straps and metal mounting brackets. The banding straps are under tension and may snap violently, causing injury. Always wear proper eye and foot protection when unpacking or installing the system.

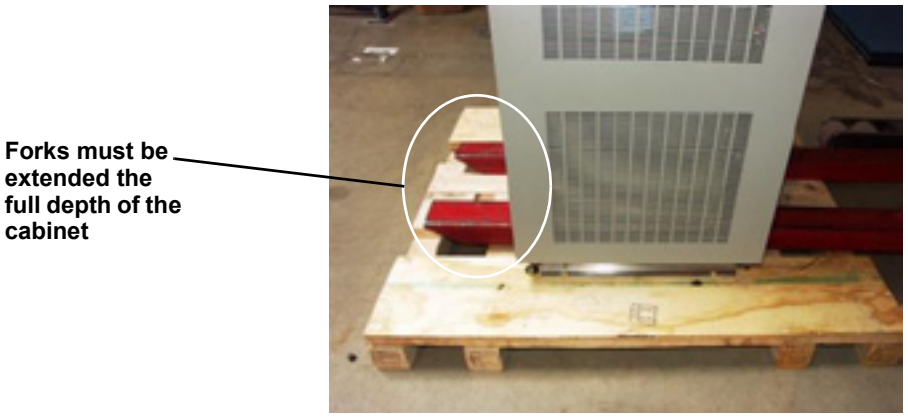
2. Remove hex head bolts holding mounting brackets to pallet as shown in **Figure 9**.
3. Remove lag bolts holding metal mounting brackets to pallet.
4. Remove mounting brackets from Liebert FS.

Figure 9 Removing lag bolts



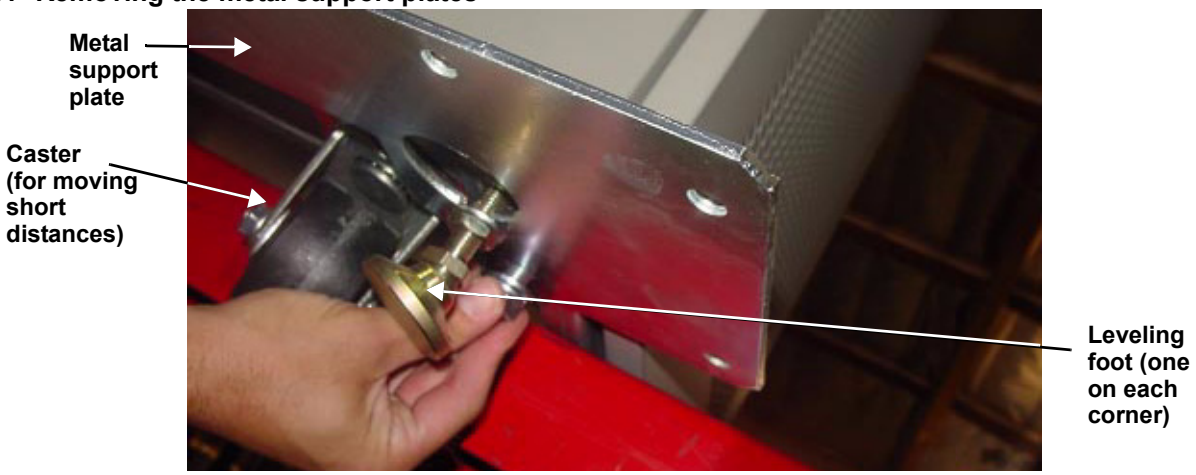
5. Use a forklift to remove the cabinet from the shipping pallet.
   To lift the Liebert FS, the forks should be inserted between the caster wheel assemblies (see **Figure 10**). Forks must be extended to the full depth of the cabinet—at least 6 ft. (2m) fork length—to properly support the equipment (see **Figure 10**). This likely requires fork extenders. The Liebert FS unit can weigh up to 1,300 lb. (590kg) and must be handled with care.

Figure 10 Lifting the Liebert FS cabinet



6. Unbolt and remove the two metal support plates (one on either side of the pallet).

Figure 11 Removing the metal support plates



NOTE
Retain the four bolts (1/2" diameter x 1-3/4" long; 12.7mm diameter x 44.5mm long) attaching the metal support plates to the cabinet. These will be used to attach brackets to the cabinet for surface mounting.

7. Examine the Liebert FS internally and externally for transit damage. Report any damage to the shipper, your local Liebert representative and Liebert immediately.

CAUTION
Do not attempt to install the system if there is any damage.

8. Check visually for loose connections and unsecured components in the cabinet.
9. You will find the installation manual, operation manual and options manual (if any) enclosed in the pocket inside the cabinet door (see **Figure 12**).
10. You will find the serial number and model number plate mounted on the cabinet door pocket or on the upper right corner of the face of the cabinet frame inside the door (see **Figure 12**). Record the model number and serial number in **Table 1 - System information**.

Figure 12 Location of serial and model number plate (cabinet side panel removed and open door)

3.3 Positioning the Liebert FS

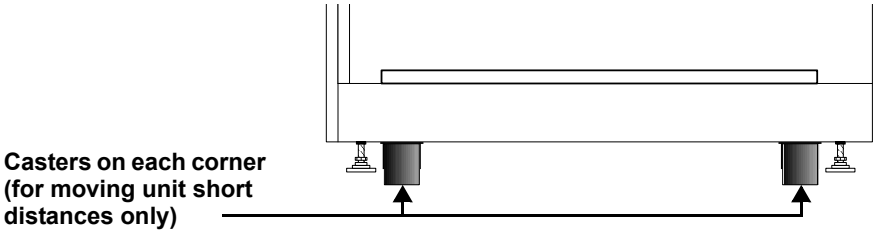
3.3.1 Moving the Liebert FS

When moving the unit a short distance, the Liebert FS may be rolled on its built-in casters (see **Figure 13**) to its location.

CAUTION

Before moving the Liebert FS across a floor, determine whether the surface will support the unit's weight—1,462 lb. (663kg) as shipped; 1,300 lb. (590kg) uncrated.

Figure 13 Liebert FS cabinet caster location



When moving the unit a longer distance or over rough flooring, move the Liebert FS with a forklift or similar equipment to facilitate the relocation and to reduce vibration of the unit.

CAUTION

Ensure that the handling equipment is rated for the weight of the Liebert FS—1,462 lb. (663kg) as shipped; 1,300 lb. (590kg) uncrated.

3.3.2 Storing the Liebert FS for Delayed Installation

If the equipment will not be installed immediately, it must be stored indoors where the temperature stays within -4°F to 176°F (-20°C to 80°C) and the humidity is no higher than 95% (non-condensing).

4.0 INSTALLATION

The Liebert FS system design and safety characteristics allow for a relatively simple and quick installation. The system is designed to be rolled or lifted into place and bolted to the floor using Liebert's mounting kit, included with the system. The mounting kit in most cases does not require any special floor preparations (see**3.0 - Unloading and Unpacking**).

CAUTION

The Liebert FS system must be installed in accordance with the instructions and drawings in this manual.

CAUTION

Never attempt to install or power up any unit suspected of damage during shipment.

CAUTION

The Initial System Startup must be performed ONLY under the supervision of a Liebert-certified service technician to ensure proper system operation. Failure to abide by instructions provided herein may void your warranty.

Contact your local Liebert sales representative or Liebert at 1-800-LIEBERT to arrange for system startup.

Figure 14 Dimensions, general layout

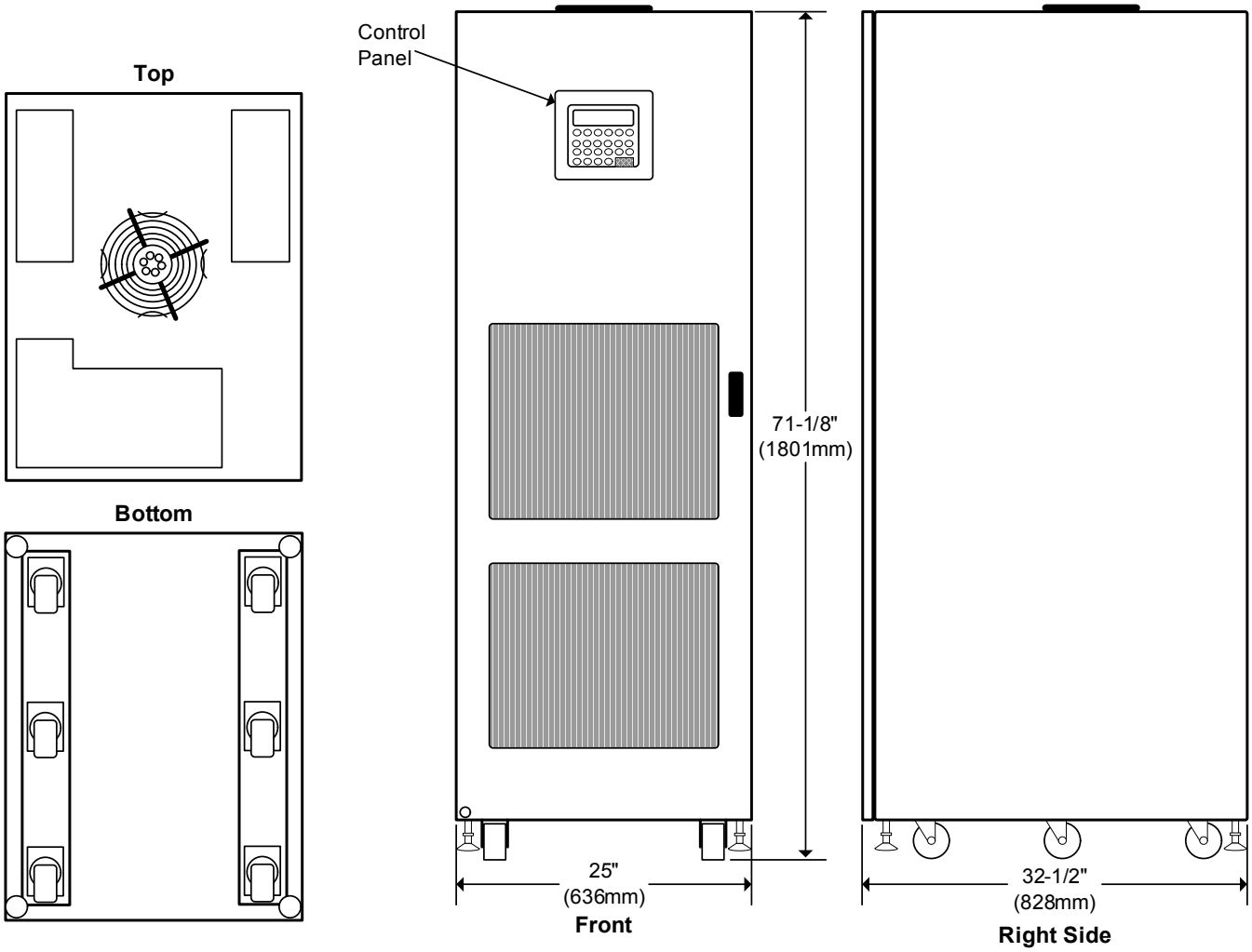
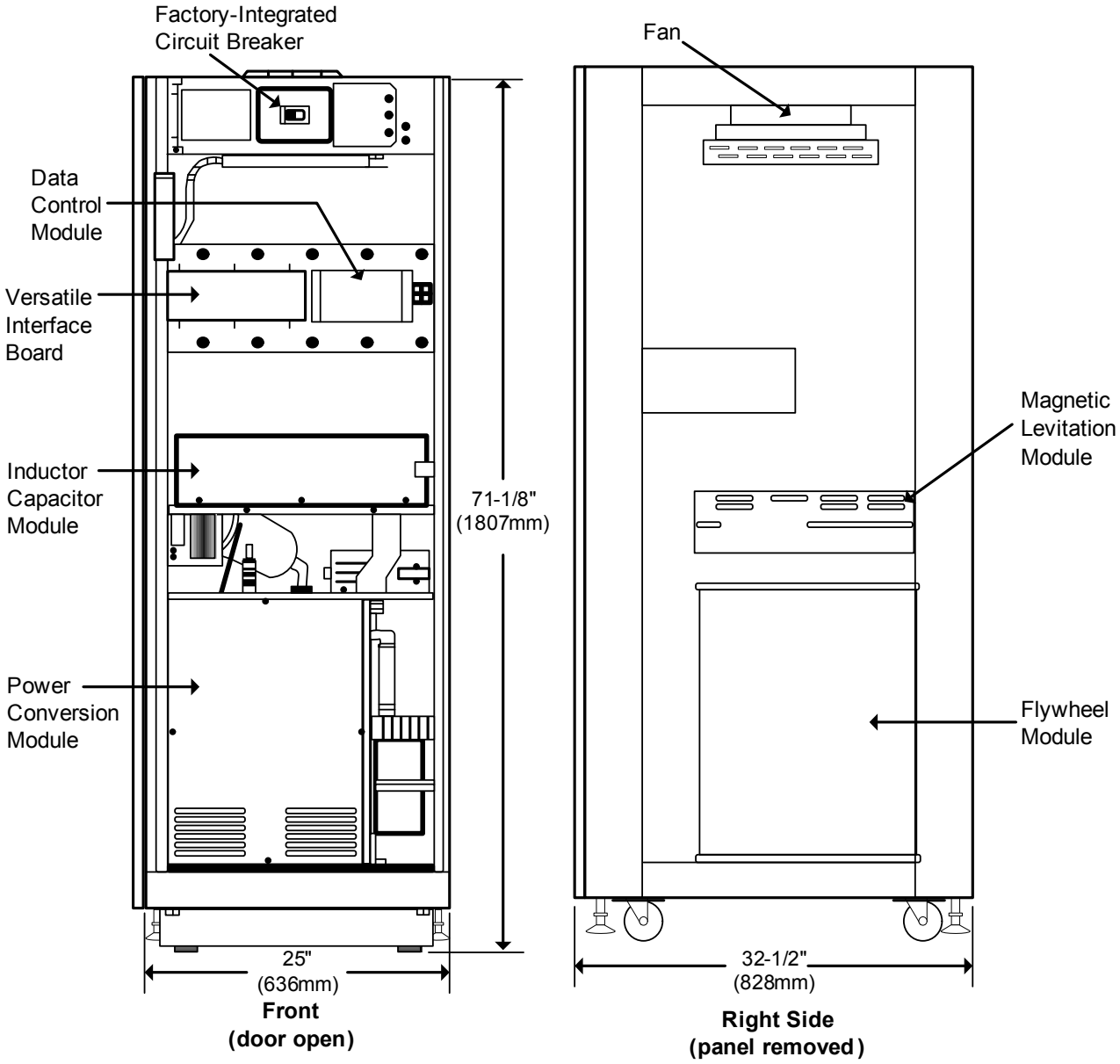


Figure 15 Internal layout



NOTE

The Liebert FS is designed for front-access-only for installation and maintenance. While the likelihood of repair is minimal, some repair procedures require side and/or rear access. Normally, the easiest way to handle this is to disconnect the power and control wiring and roll the unit out into an open area on its casters. While it is acceptable, under certain circumstances, to connect the Liebert FS to its companion UPS unit through the sides of the Liebert FS and UPS cabinets rather than through external conduit, repair access to the Liebert FS unit will be easier to facilitate if through-cabinet wiring is not installed.

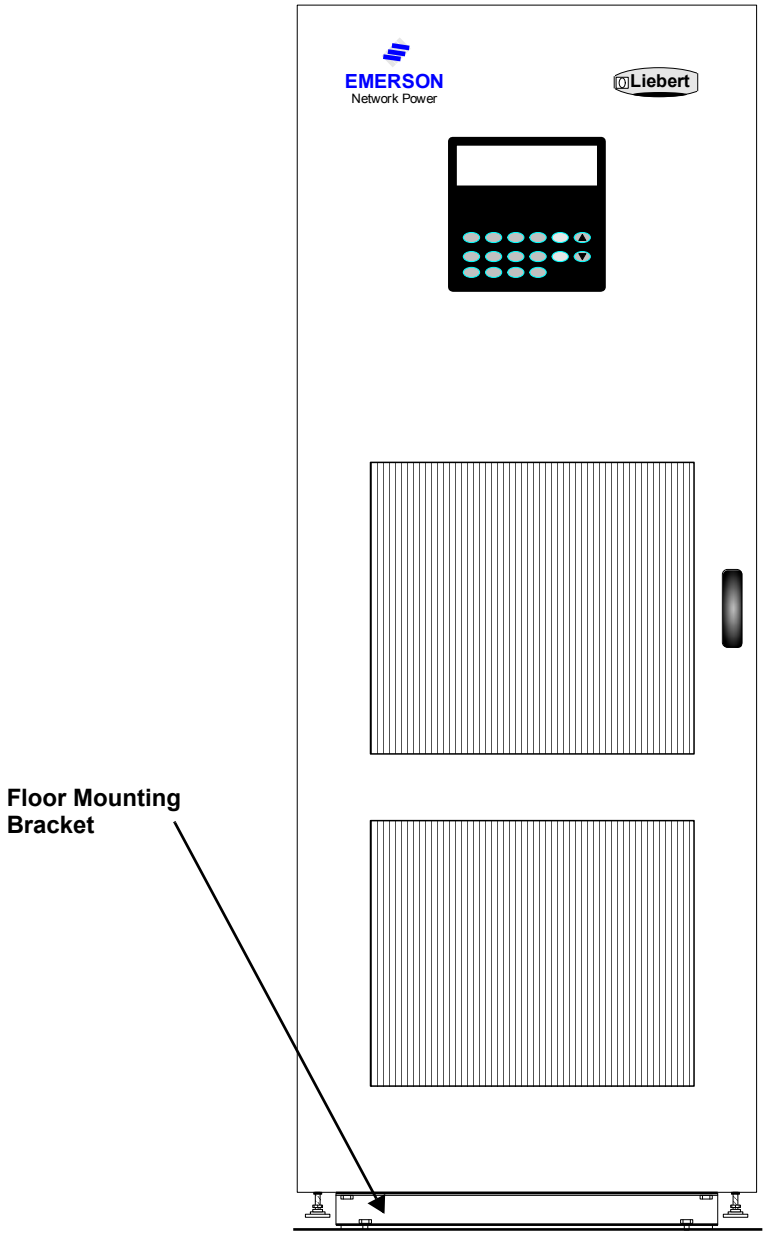
4.1 Cabinet Floor Mounting

NOTE

*Before beginning, ensure that the floor where the Liebert FS will be mounted meets the floor loading specifications in **2.3 - Flooring Requirements**.*

- For placement on concrete, masonry or stone floors, see **4.1.1 - Concrete, Masonry or Stone Floor Mounting**.
- For placement on wood floors, see **4.1.2 - Wood Floor Mounting**.
- For placement on raised floors, see **4.1.3 - Raised Floor Mounting**.

Figure 16 Floor mounting



NOTE

*All drawings referred to in this section are in **Appendix D.0 - Installation Drawings**.*

4.1.1 Concrete, Masonry or Stone Floor Mounting

Mounting Kit for Concrete, Masonry or Stone Floors

Liebert has included a complete anchoring kit with each Liebert FS for surface mounting. The kit is intended to securely fasten the Liebert FS to its intended location for operational safety and seismic requirements.

This kit includes (items depicted in **Figure 150**):

- Two (2) cabinet mounting brackets (from shipping pallet)
- Four (4) concrete expansion anchors
- Two (2) drop-in hex head anchor bolts
- Two (2) washers for anchor bolts
- One (1) masonry drill bit
- One (1) floor mounting template (**Figure 149**)
- Two (2) drop-in hex flange anchor bolts
- One (1) setter rod or drive pin (specifically designed for measuring hole depth and for expanding the anchors)
- Four (4) hex bolts from shipping package, each 1/2" diameter and 3/4" long (12.7mm diameter x 20mm long)

Mounting Tools

These tools are needed for the mounting the Liebert FS on the floor:

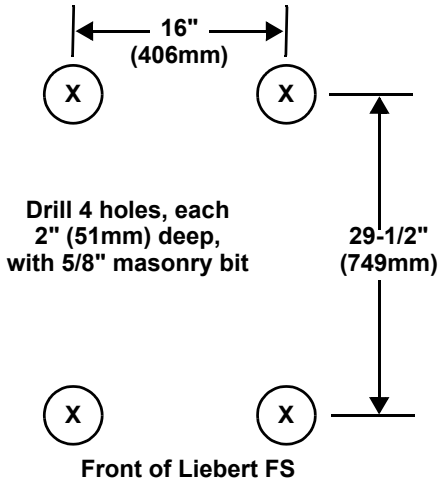
- Concrete drill with 1/2" (12.7mm) minimum chuck size
- Masonry drill bit (included in mounting kit)
- Masonry drill bit—used for pilot hole—for example, 1/8" (3.2mm) diameter
- Setter rod (included in mounting kit)
- Hammer or mallet, 16 oz. (0.5kg) or larger
- Shop vacuum cleaner (to remove dust from hole when drilling)
- 3/4" (19mm) combination wrench
- 18mm combination wrench

Concrete, Masonry or Stone Floor Mounting Instructions

To mount the Liebert FS cabinet on the floor:

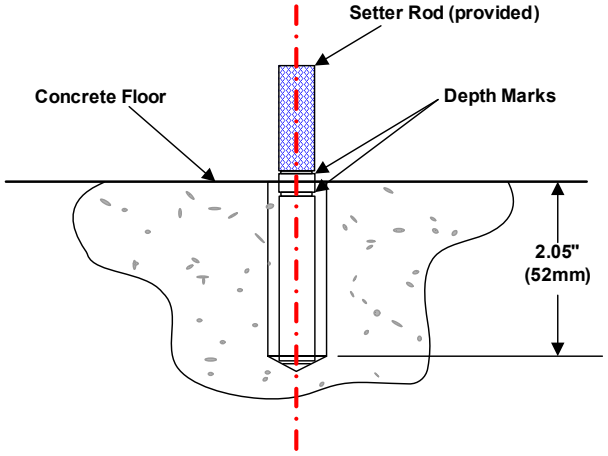
1. Prepare a clean, level, finished surface, free of obstructions, for installation of the mounting kit.
2. Tape the floor mounting template mounting template (**Figure 149**) to the installation location.
3. Using a bit smaller than the one provided in the mounting kit, drill a pilot hole at each of the four places marked with an “X” on the template.
4. Remove template and continue with larger drill bit provided.

Figure 17 Floor mounting template layout



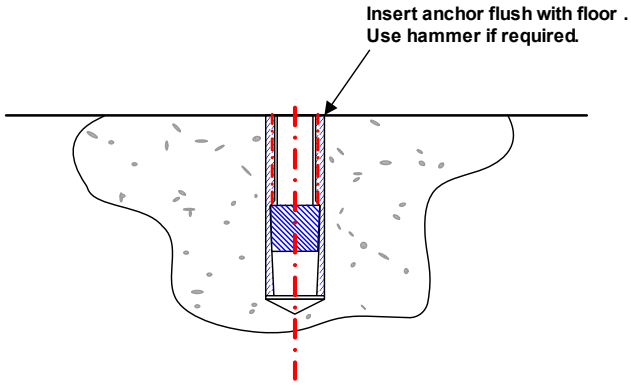
5. Drill 2" (51mm) deep holes in prepared surface using the drill bit included in the kit per bolt pattern described in **Figure 149 - Floor mounting template**. The setter rod should be used as a depth gauge to ensure proper depth. The setter rod is marked with two circles indicating the maximum and minimum hole depth allowed (see **Figure 18**).
   If a hole is drilled too deep, refill the hole with debris to the achieve proper depth.

Figure 18 Checking hole depth



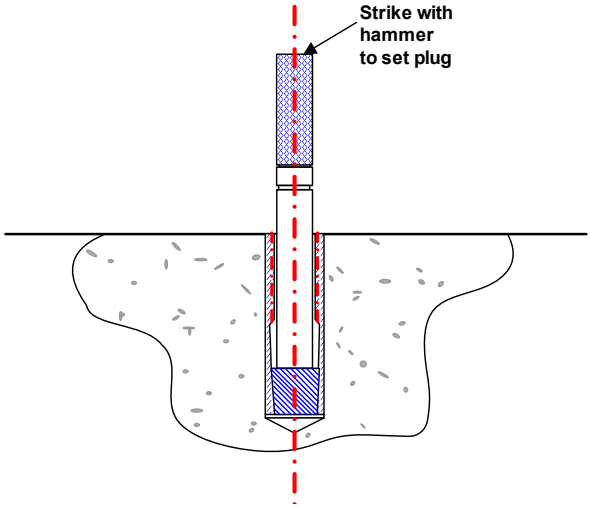
6. Insert four (4) drop-in concrete expansion anchors into drilled holes.

Figure 19 Inserting anchors



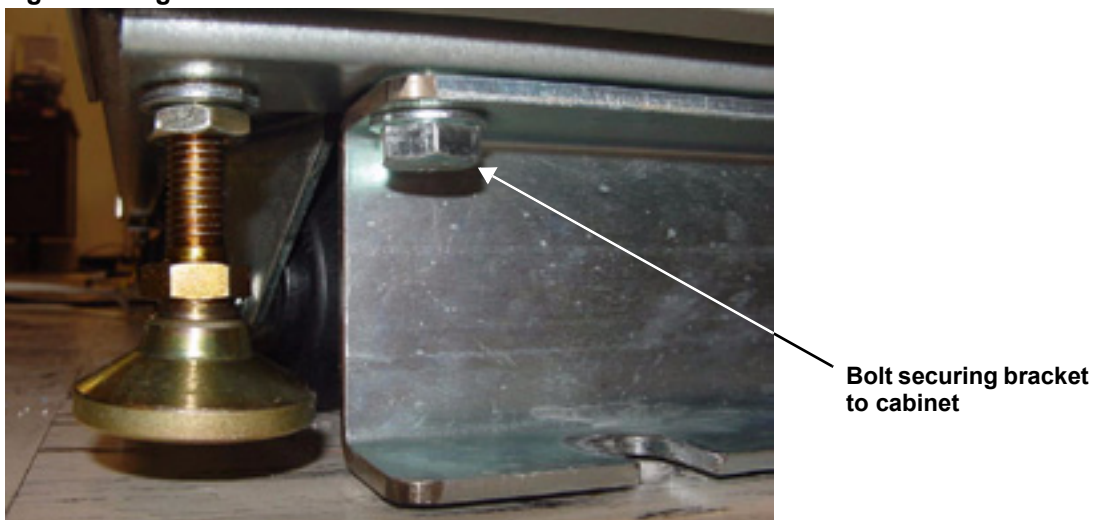
7. Tap anchors into drilled holes using hammer or mallet. When top of anchor is flush with mounting surface, use setter rod to expand and secure.

Figure 20 Expanding anchors



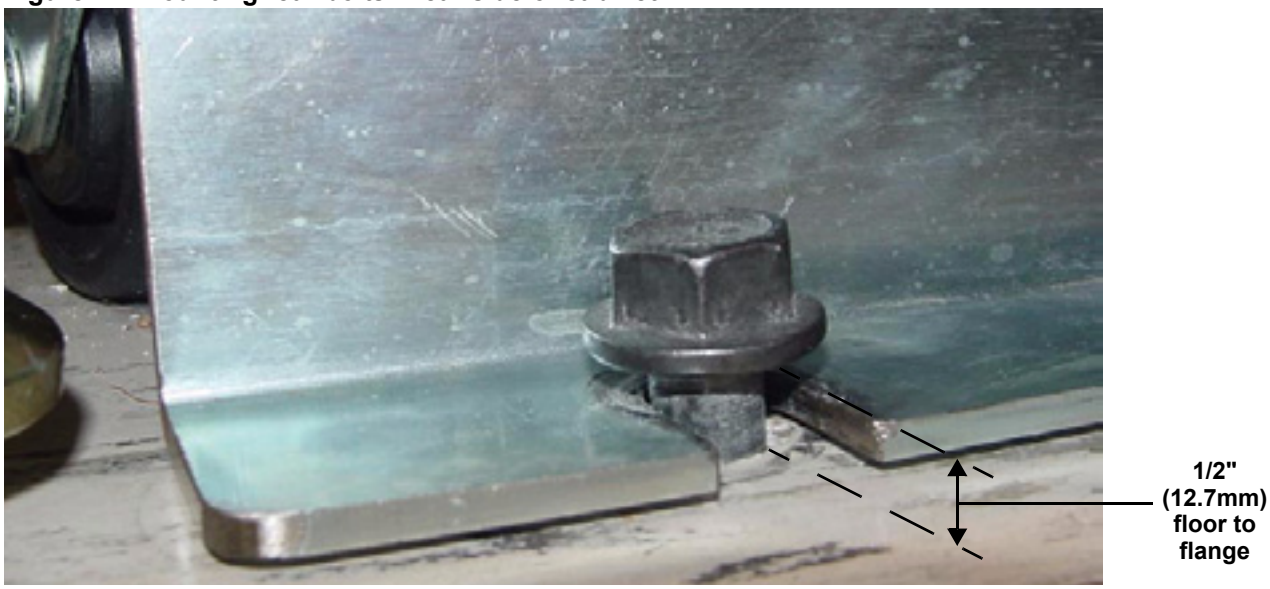
8. Match mounting brackets with the holes on the bottom of the cabinet (see **Figure 21**). Make sure that the bracket holes align with the mounting spots on the underside of the cabinet and secure the brackets with the four (4) 1/2" diameter x 3/4" long (12.7mm diameter x 20mm long) hex bolts retained from the shipping package. Tighten the bolts with a torque of 40 foot-pounds (54 N-m).

Figure 21 Securing mounting brackets to the cabinet



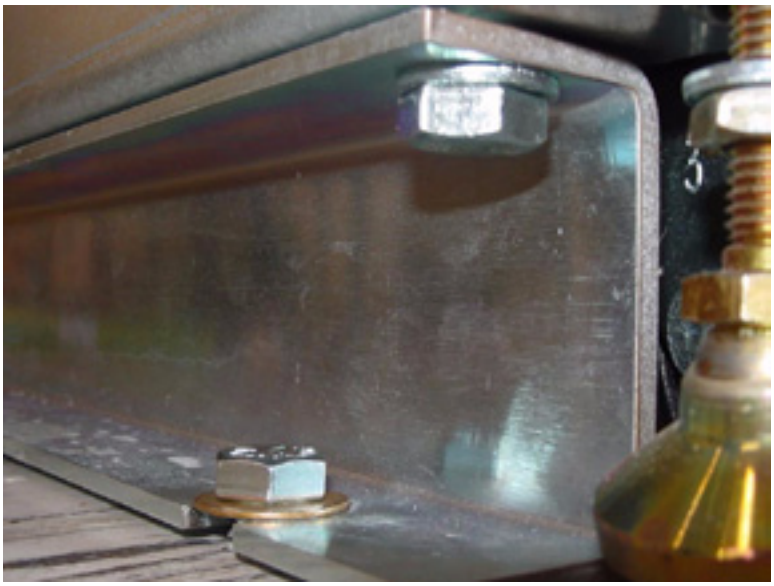
9. Insert the two (2) hex flange bolts in the rear anchors, where the back of the cabinet will be. Complete tightening of the rear bolts should result in 1/2" (12.7mm) gap between bolt flange and floor (see **Figure 22** and **Figure 134**). The rear bolts must be tightened to 20 foot-pounds (27 N-m) of torque. Bolt height or length may need to be adjusted if mounting surface is uneven or if mounting bracket does not slide beneath bolt flange.
10. Position and align cabinet and bracket slots with the newly inserted bolts at rear and position cabinet such that bolts fit in bracket slots (see **Figure 22**).

Figure 22 Mounting rear bolts—rear side of cabinet



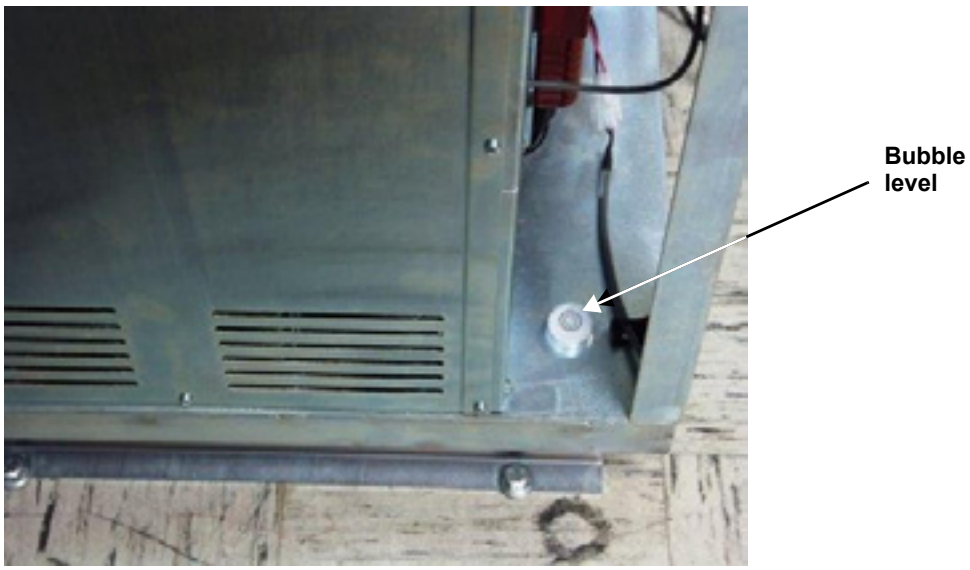
11. Insert and begin tightening two (2) hex head bolts with one washer each through bracket mounted at front of cabinet into anchor inserts in mounting surface (see **Figure 23**).

Figure 23 Mounting front bolts—front side of cabinet



12. Check the bubble level on the floor of the cabinet on the right hand side of the Power Conversion Module (see **Figure 24**). The Liebert FS is sufficiently level when the bubble is within the outer of the two circles. If the bubble is outside the outer circle, use the leveling feet to adjust until bubble is within the outer circle.

Figure 24 Bubble level



13. Once the cabinet is level, firmly tighten the front bolts to drop-in anchors as shown in **Figure 134**. The front bolts must be tightened to 40 foot-pounds (54 N-m) of torque.

4.1.2 Wood Floor Mounting

Determine which of these cases applies to your installation:

- For wood flooring over concrete, follow the instructions in **4.1.1 - Concrete, Masonry or Stone Floor Mounting**.
- For wood flooring on joists, follow the instructions in this section.

Wood Floor Mounting Parts

- Two (2) cabinet mounting brackets (previously secured Liebert FS cabinet to shipping pallet)
- Four (4) (1/2" diameter x 2-1/2" long) [or 12.7mm diameter x 63.5mm] lag screws (not included in mounting kit) are recommended
- One floor mounting template, see **Figure 149**
- Four (4) 1/2" diameter x 3/4" long (12.7mm diameter x 20mm long) hex bolts (from shipping package—see **3.2.2 - Unpacking**)

Wood Floor Mounting Tools

The following tools are needed for the cabinet wood floor mounting:

- Electric drill
- 1/4" (7mm) drill bit
- Drill bit—used for pilot hole—for example, 1/8" (3.2mm) diameter
- Shop vacuum cleaner (to remove dust from hole when drilling)
- 3/4" (19mm) combination wrench
- 18mm combination wrench

Wood Floor Mounting Instructions

Installation in wood floor on joists does not require drop-in anchors.

1. Prepare a clean, level surface, free of obstructions, for installation of the mounting kit.
2. Tape the floor mounting template (**Figure 149**) to the installation location.
3. Drill pilot holes, remove the template and use a 1/4" (7mm) drill bit to drill holes 2.5" (64mm) deep.

CAUTION
Ensure that holes are centered in the joist.

4. Match mounting brackets with holes under base of cabinet (see **Figure 21**). Make sure that the bracket holes align with the mounting spots on the underside of the cabinet and secure brackets with the four hex bolts retained from the shipping package. Each bolt is 1/2" diameter x 3/4" long (12.7mm diameter x 20mm long). Tighten the bolts with a torque wrench at 40 foot-pounds (54 N-m).
5. Insert two lag screws through bracket mounted at rear of cabinet leaving head with 1/2" (12.7mm) gap above floor (see **Figure 22**).
6. Position and align cabinet and bracket slots with the newly drilled holes at rear and position cabinet such that bolts fit in bracket slots (see **Figure 22**).
7. Insert two (2) lag screws through bracket mounted at front of cabinet (see **Figure 23**).
8. Check the bubble level on the floor of the cabinet on the right hand side of the Power Conversion Module (see **Figure 24**). The Liebert FS is sufficiently level when the bubble is within the outer of the two circles. If the bubble is outside the outer circle, use the leveling feet to adjust until bubble is within the outer circle.
9. Once the cabinet is level, firmly tighten the front lag screws to a torque 40 foot-pounds (54 N-m).

4.1.3 Raised Floor Mounting

Raised Floor Mounting Kit

Liebert has included a complete anchoring kit with each Liebert FS for surface mounting. The kit is intended to securely fasten the Liebert FS to its location for operational safety and seismic requirements.

The anchoring kit includes:

- One floor mounting template, **Figure 149**
- 2 cabinet mounting brackets
- 4 drop-in hex flange bolts, each 1/2" diameter, 3" long (12.7mm, 76.mm)
- 4 washers (1/2" hole and 2" outer diameter) for hex flange bolts
- 4 lock washers for hex flange bolts
- 4 nuts for hex flange bolts, each 1/2" (12.7mm)
- 4 hex bolts, each 1/2" diameter, 3/4" long (12.7mm diameter, 20mm long) retained from shipping package *(*see **3.2.2 - Unpacking***)*

Raised Floor Mounting Tools

The following tools are needed for the cabinet raised floor mounting:

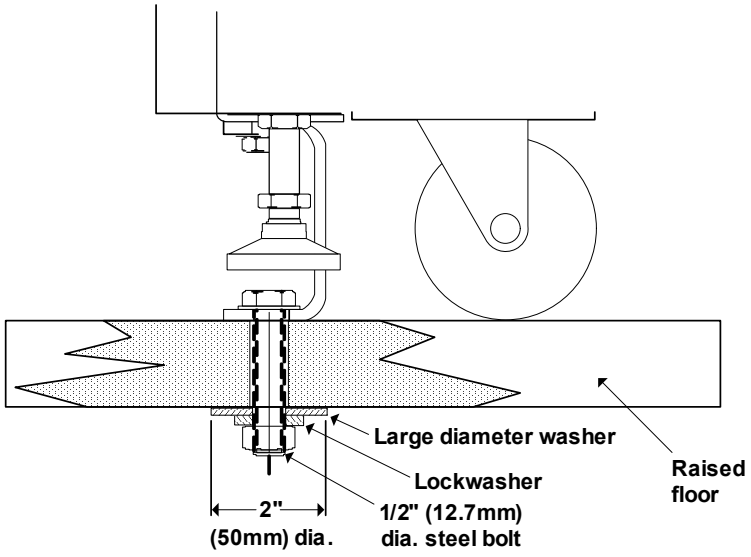
- Electric drill with 1/2" (12.7mm) minimum chuck size
- 5/8" (16mm) drill bit
- Drill bit—used for pilot hole—for example, 1/8" (3.2mm) diameter
- 3/4" (19mm) combination wrench
- 18mm combination wrench

Raised Floor Mounting Instructions

To mount the Liebert FS cabinet on the floor:

1. Prepare a clean, level finished surface, free of obstructions, for installation of mounting kit.
2. Tape the floor mounting template (see **Figure 149**) to installation location, pre-drill a pilot hole, then remove paper and continue with 5/8" (16mm) drill bit.
3. Match mounting brackets with holes under base of cabinet (see **Figure 21**). Make sure that the bracket holes align with the mounting spots on the underside of the cabinet and secure brackets with the four 1/2" diameter x 3/4" long (12.7mm diameter x 20mm long) hex bolts retained from the shipping package. The bolts must be tightened to 40 foot-pounds (54 N-m) of torque.
4. Position and align cabinet and bracket slots with the newly drilled holes (see **Figure 22**).
5. Insert four drop-in hex flange bolts through bracket mounted at front and rear of cabinet (see **Figure 23**).

Figure 25 Raised floor mounting



6. Attach a large diameter washer, a lock washer and a nut to each hex flange bolts as described in **Figure 25** and **Figure 155**.
7. Check the bubble level on the floor of the cabinet on the right hand side of the Power Conversion Module (see **Figure 24**). The Liebert FS is sufficiently level when the bubble is within the outer of the two circles. If the bubble is outside the outer circle, use the leveling feet to adjust until bubble is within the outer circle.
8. Once cabinet is level, firmly tighten down all hex flange bolts with nuts. The bolts must be tightened to 40 foot-pounds (54 N-m) of torque.

4.2 Wiring Connections

4.2.1 General Wiring Considerations

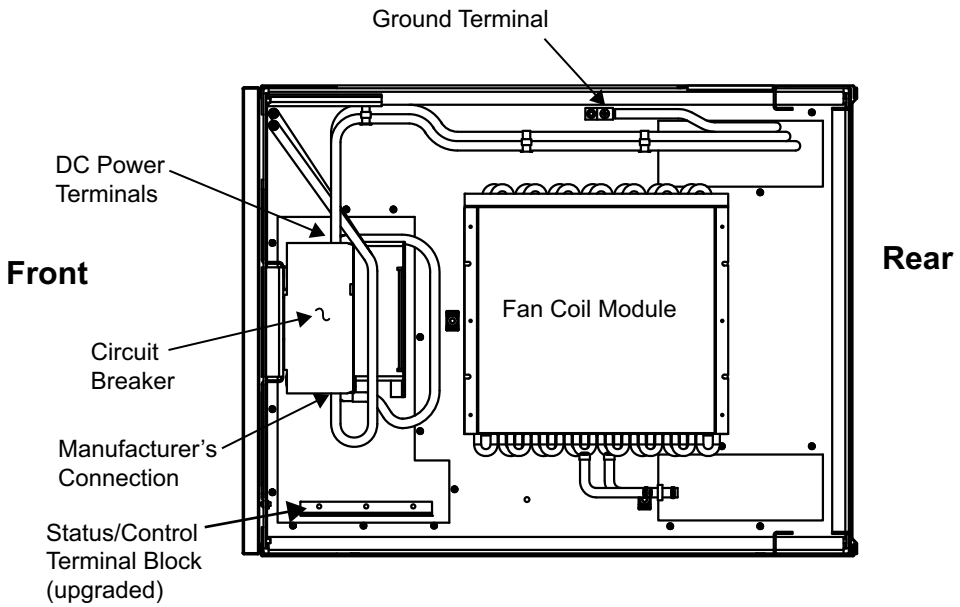
CAUTION

A qualified electrical contractor must perform all electrical connections. The wires (DC power, ground, upgraded status/control and auxiliary power supply) that connect the Liebert FS system(s) to the UPS system are field-supplied or by Liebert as an option. Wire size and installation must comply with all applicable local, regional and national regulations (e.g., National Electric Code for USA).

The electrical connections to the Liebert FS are:

- DC power
- Status/control (upgraded)
- Ground
- Auxiliary backup power
- Remote monitoring—optional

Figure 26 Liebert FS cabinet with UPS interconnection kit



Power and Status/Control wiring must be run in separate conduits or cable trays. Refer to **Appendix D.0 - Installation Drawings** for locations of the various electrical connections between Liebert FS system(s) and UPS system.

CAUTION

Power and Status/Control wiring must be separated.

CAUTION

Do not cut entry holes for conduit while the access plates are still set on the top of the Liebert FS cabinet. Remove the access plates from the cable-access areas in the top of the Liebert FS cabinet prior to cutting entry holes in them.

CAUTION

After reinstalling access plates, be certain that no foreign matter (metal shavings, insulation or wire fragments, etc.) remains inside the Liebert FS. Likewise, be certain to block any "extra holes" in the plates through which foreign matter (or rodents) could later enter the Liebert FS.

CAUTION

The instructions for installation of DC Power AND Status/Control connections vary according to the type of UPS interconnection kit that is integrated into your Liebert FS unit.

Figure 27 Liebert FS with circuit breaker mounting plate and access panels for DC and control wiring connections

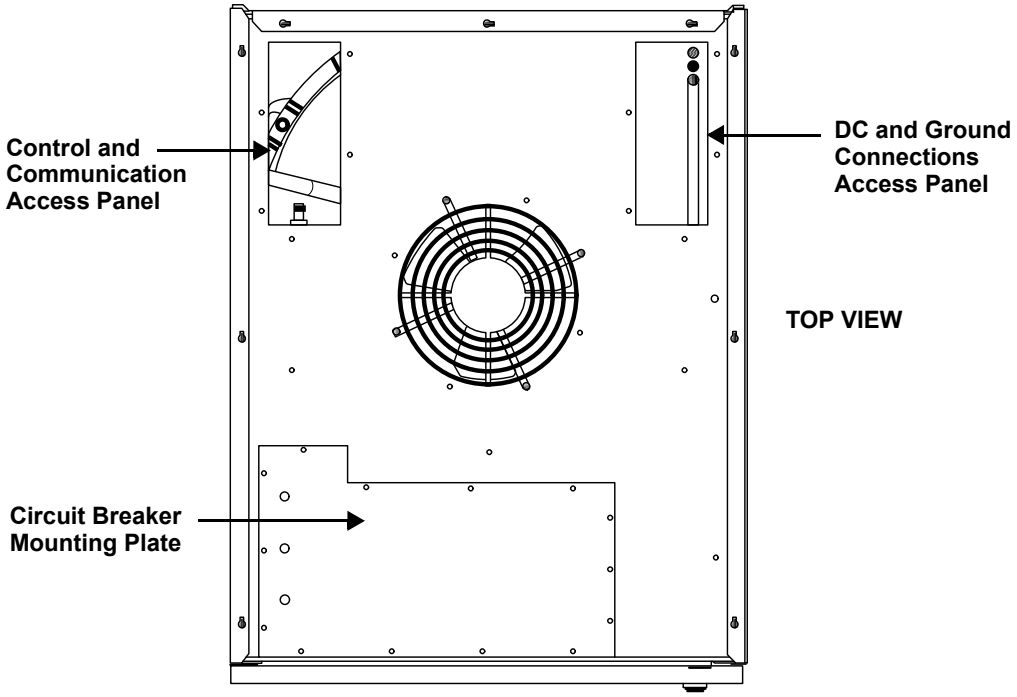
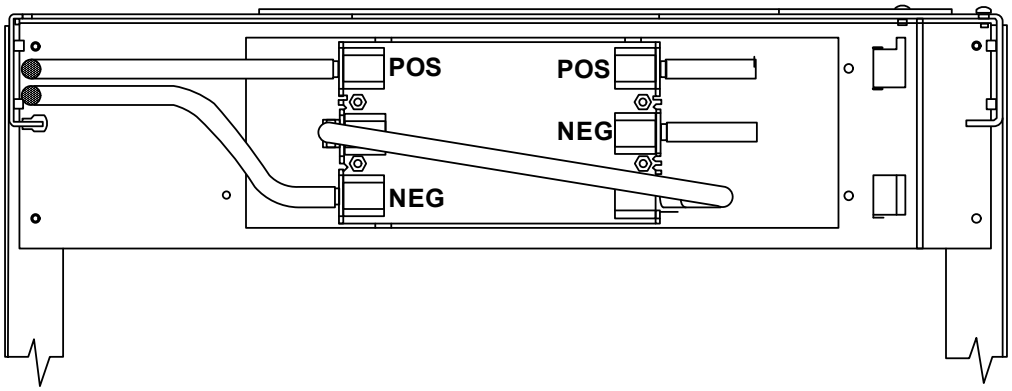


Figure 28 Typical circuit breaker wiring for DC connections (view from rear of circuit breaker)



4.2.2 DC Power Connections

The instructions for installation of DC power connections vary according to the type of UPS interconnection kit integrated into your Liebert FS unit. Follow the installation instructions in **Appendix A.0 - UPS Interconnection Kits** for the relevant UPS interconnection kit installed in your unit.

4.2.3 Status/Control Connections

The instructions for installing Status/Control connections vary according to the type of UPS interconnection kit that is integrated into your Liebert FS. Follow the installation instructions in **Appendix A.0 - UPS Interconnection Kits** for the relevant UPS interconnection kit installed in your unit.

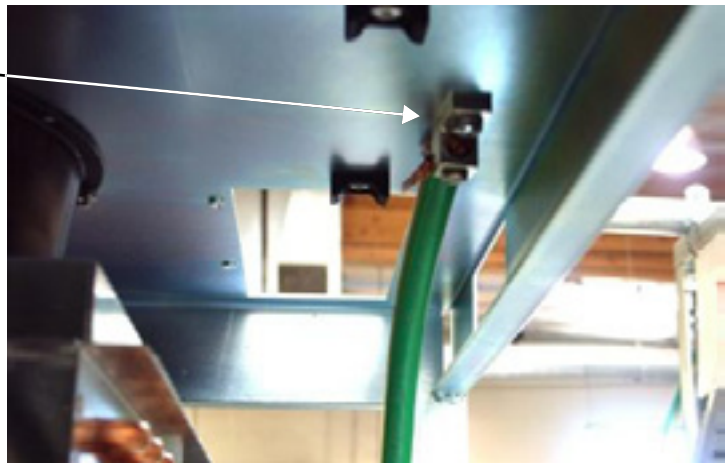
4.2.4 Ground Connections

A ground connection is available on the Liebert FS (see **Figure 29**). The electrical contractor must ensure that the Liebert FS is effectively grounded to UPS chassis or UPS ground terminal. The ground connection must be as short as possible. The maximum ground wire size is 1/0 AWG - 600VDC wire (54mm^2 wire section). Wire size and installation must comply with all applicable local, regional and national regulations (e.g., National Electric Code for USA). Check all connections with Multimeter to verify ground continuity. (Refer also to **Appendix E.1 - Ground Test Procedure**.

CAUTION

Ensure that all grounds are secure and free of corrosion. Proper grounding is necessary for optimum performance, safety and reliability.

Figure 29 Ground connection on the Liebert FS



The tightening torque for the ground connections must be in accordance with **Table 3**. Use these values unless the equipment is labeled with a different torque value.

Table 3 Tightening torque for ground connection

Ground Wire Gauge		Tightening Torque	
AWG	Approximate metric equivalent wire section (mm^2)	Inch-pounds	N-m
4	21	110	12
2	34	150	17
1	42	150	17
1/0	54	180	20

4.2.5 AC Auxiliary Control Power Supply Connections

The AC auxiliary power supply connections to the Liebert FS are made through the auxiliary power fused disconnect on the mounting plate above the inductor-capacitor module and to the right of the optional VIB and DCM modules (see **Figure 30**). See **Appendix F.0 - Auxiliary Backup AC Power Supply** for details on the purpose of the auxiliary AC power supply.

Figure 30 Service panel location

The Auxiliary Power Fused Disconnect (see **Figure 31**) accommodates the connection of an AC wire (Line, Neutral, Ground) and is rated for 110/230 VAC - 50/60 Hz. Open the circuit while wiring, check the fuses and then close it. The AC wire must be connected to the auxiliary power fused disconnect from the top to a dedicated AC circuit rated for 500VA with branch circuit protection. This AC outlet must be connected to a protected low-voltage (110VAC-230VAC, 500VA) source. A qualified electrical contractor should make this connection permanent.

The AC wire is field-supplied. It must conform to all applicable local, regional, national regulations, such as the National Electric Code for USA. An 18 AWG (0.82 mm^2) cable is recommended for this connection.

Tighten the connections for the 18 AWG cable (0.82 mm^2) to 15 inch-pounds (1.6N-m).

Figure 31 Auxiliary backup power connections

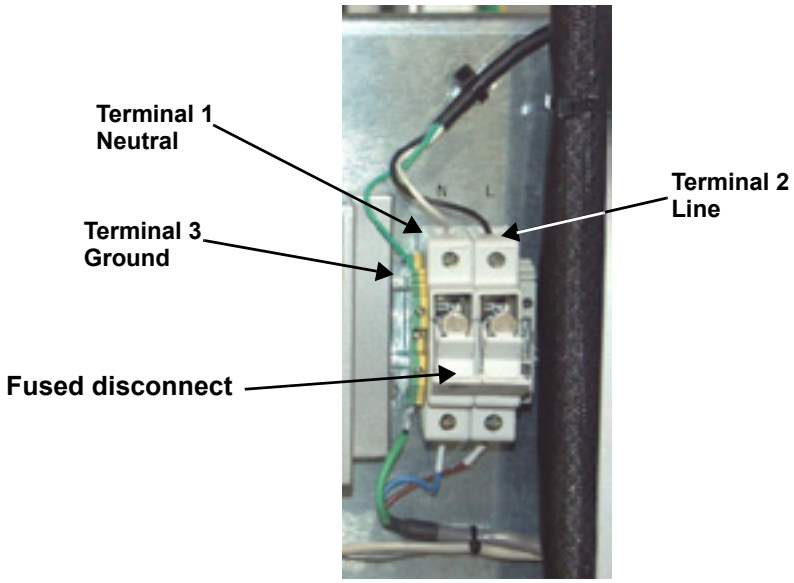
CAUTION

The AC power supply must remain connected at all times. Precautions must be taken to ensure that the connection is not broken. Disconnection may cause damage to the equipment.

The AC wire is field-supplied. Wire size and installation must comply with all applicable local, regional and national regulations (e.g., National Electric Code for USA). An 18 AWG cable (approximate metric equivalent: 0.82mm^2 wire section) is recommended for this connection.

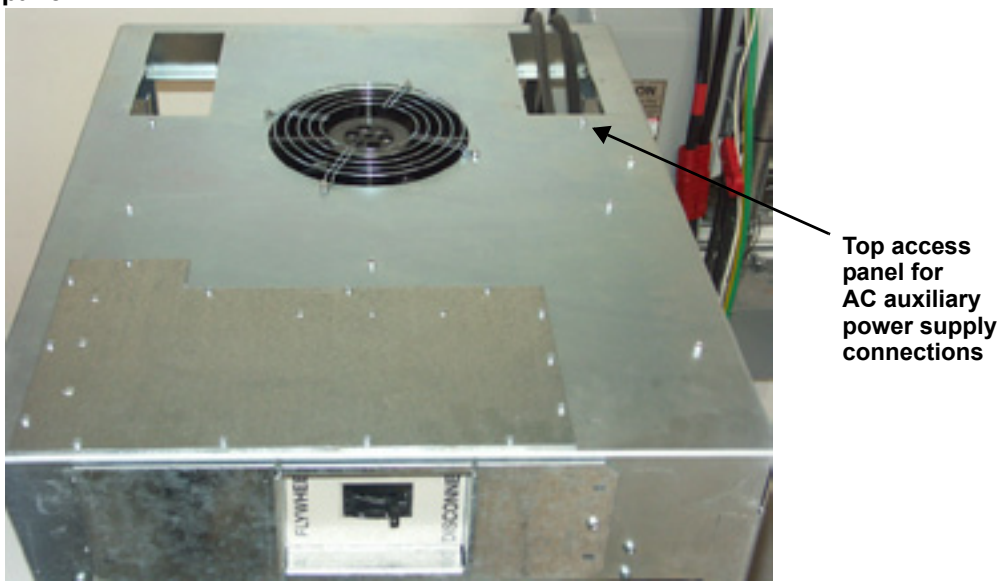
Figure 32 shows the auxiliary power fused disconnect and terminals 1, 2 and 3, the landing points for the AC wire on the Liebert FS side. Open the circuit while wiring, check the fuses and close afterwards when ready to test or start up Liebert FS.

Figure 32 Auxiliary power fused disconnect with connection points for AC wire



The AC wire should be pulled from the left (top access recommended) and through the rear top access panel (see **Figure 33**). Run the AC wire along the underside of the top cabinet frame rail from the rear to the front of the cabinet. Terminate the AC wire at the fused disconnect (pictured in **Figure 32**; see also **Figure 26**).

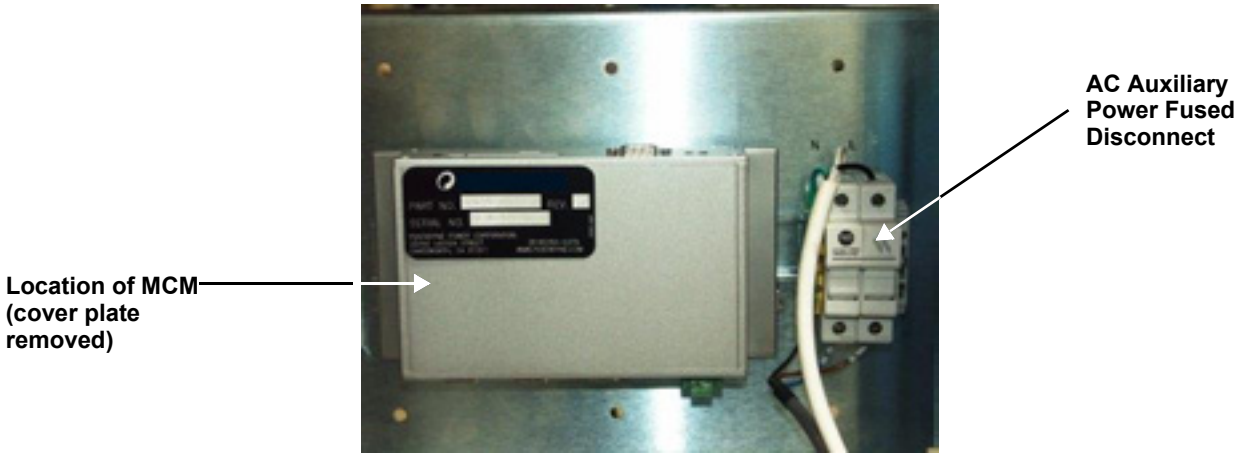
Figure 33 Top access panel



4.2.6 Remote Monitoring Connections—Optional

The Liebert FS standard unit does not include remote monitoring connections. Remote monitoring capabilities are provided as an option see **Figure 34**). If your unit is equipped with the optional Data Collection Module (DCM), refer to the installation and configuration instructions in **Appendix B.0 - Data Collection Module**.

Figure 34 Remote monitoring (DCM) connections (inside cabinet front door)



4.3 Startup Considerations

CAUTION

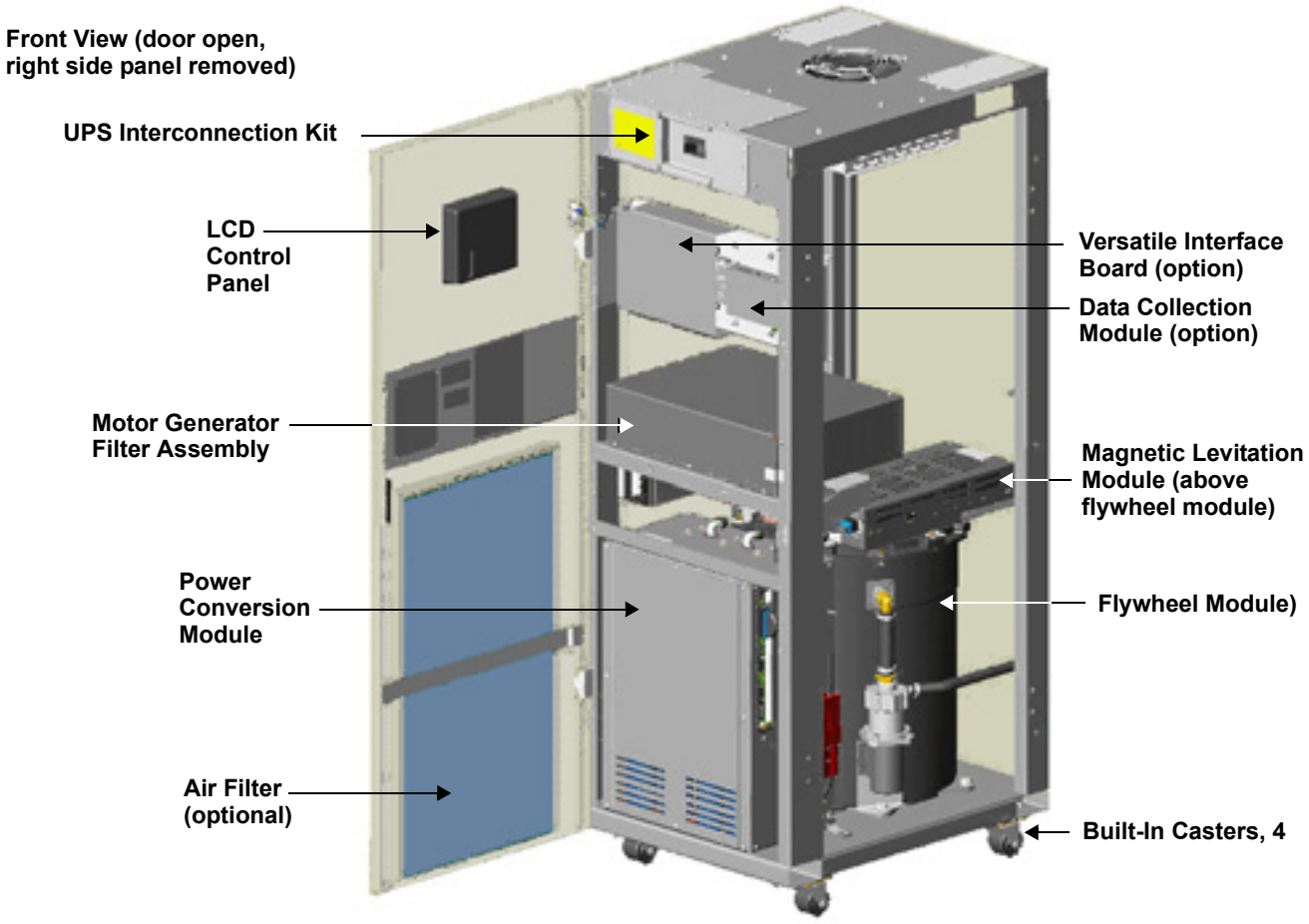
The Initial System Startup must be performed ONLY under the supervision of a Liebert-certified service technician to ensure proper system operation. Failure to abide by instructions provided herein may void your warranty.

Contact your local Liebert representative or call 1-800-LIEBERT to arrange for system startup.

5.0 System Overview

5.1 Detailed System Description

Figure 35 Liebert FS front view



5.1.1 System Module Description

The Liebert FS is a modular system composed as follows:

- Control Panel
- UPS Interconnection Kit
- Power Conversion Module
- Main Control Module
- Flywheel Module
- E-Stop (optional-special order)

Components are illustrated in **Figure 35**.

Control Panel

The Liebert FS uses a control panel as the primary means for an operator to interface with the system.

UPS Interconnection Kit

The UPS Interconnection Kit is a module that enables the physical interconnection of the Liebert FS and a UPS system. There are several versions that vary, depending on the UPS model.

The Liebert FS is delivered with a UPS interconnection kit consisting of a circuit breaker for connection of the positive and negative terminals coming from the UPS DC bus or from an external disconnect switch.

Power Conversion Module

The power conversion module is a bi-directional power electronics-based power converter capable of sourcing or sinking power to and from the UPS DC bus.

While performing the Liebert FS's backup power mission, the power conversion module converts "variable frequency - variable voltage" AC power from the Liebert FS' motor-generator and delivers regulated DC voltage output to the UPS DC bus.

Conversely, for the Liebert FS's needs in charging power, the power conversion module converts DC power from the UPS DC bus into "variable frequency - variable voltage" AC power for the Liebert FS' motor-generator.

Main Control Module

The Main Control Module provides the overall control of the Liebert FS as well as the specific control for:

- Motor-generator
- Active magnetic levitation hardware

Flywheel Module

The Flywheel Module houses several major components:

- Motor-generator—synchronous reluctance technology
- Rotating group—high-speed carbon composite flywheel, high-speed shaft and rotor of the motor-generator
- 5-axis active magnetic levitation hardware
- Molecular vacuum pump

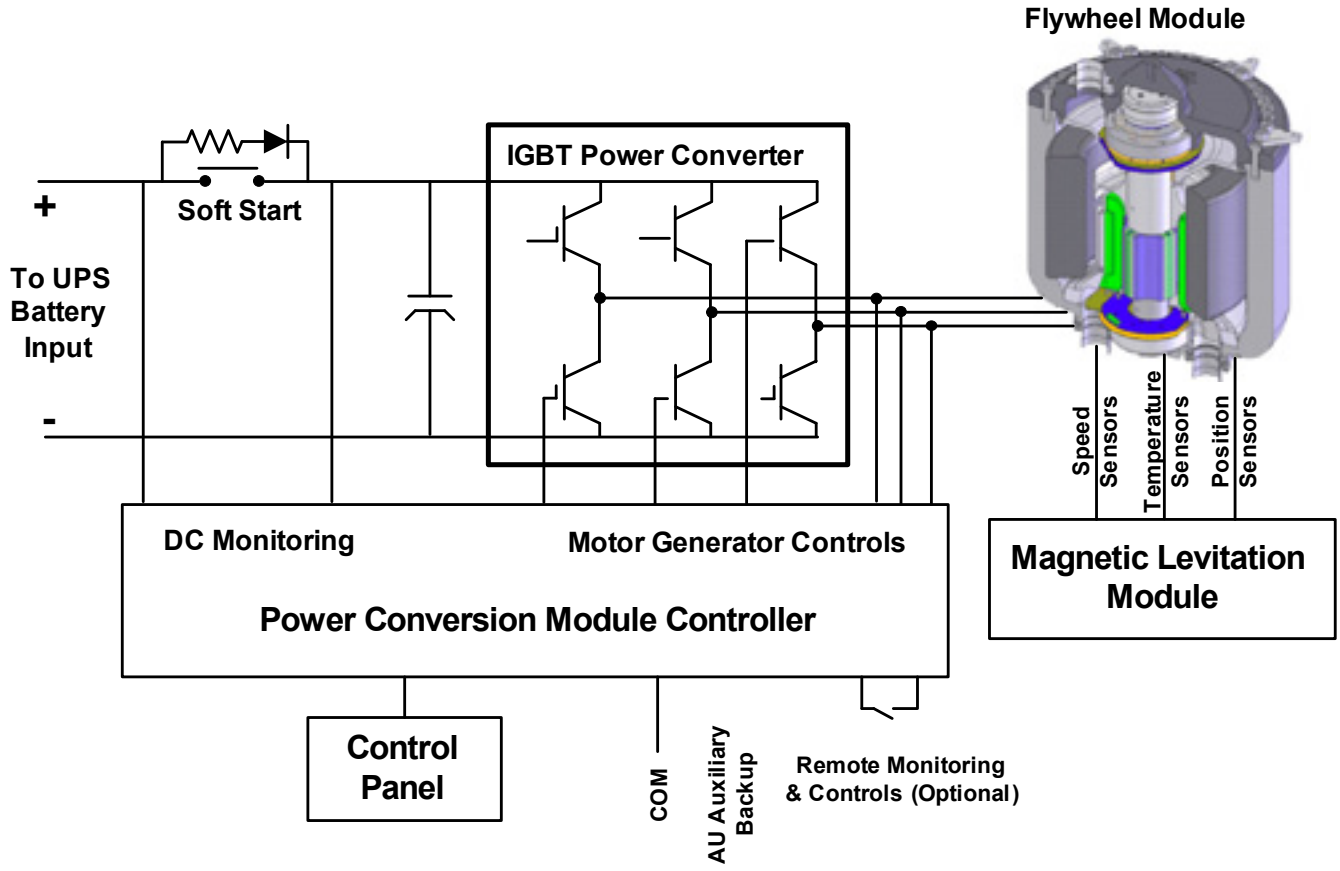
E-Stop

The E-Stop is an Emergency Stop that allows the Liebert FS to disconnect from the UPS. The E-Stop is a CE requirement for systems shipping to Europe (and other areas requiring the CE Mark). The feature is available elsewhere as an option. Two choices are available for how the E-Stop is powered, internally or externally. If E-Stop is activated, Liebert FS will enter a self-discharge and shutdown mode.

5.1.2 Power System

The electrical system of the Liebert FS is shown in **Figure 36**. The schematic shows the Magnetic Levitation Module [see **5.1.7 - Magnetic Levitation Module (MLM)**]. The pre-charge resistor and contactor which limit the inrush current into the DC bus capacitors. The six-pulse IGBT power converter (**IGBT Power Conversion Module (PCM) on page 36**) which is controlled by the Power Conversion Module Controller (**Power Conversion Module on page 33**) and which also monitors and controls the operation of the entire system. These components are housed within the Power Conversion Module. The Flywheel Module is shown as a cross-section to illustrate the rotating group and the synchronous reluctance motor-generator.

Figure 36 Electrical system schematic



5.1.3 System Performance

The maximum output power of the Liebert FS varies according to the duration required. This is illustrated in **Figure 5** (output power versus time). Increased power, duration or redundancy may be achieved by adding units in parallel as shown in **Figures 2** through **4**.

5.1.4 User interfaces

Control Panel

The Liebert FS uses a Control Panel as the primary means for an operator to interface with the system. Operating parameter values are displayed and updated in real time. Alarm states and system notices are also displayed when they occur. User configurable system parameters are adjusted via the Control Panel.

Data Collection Module (DCM)

An optional software and hardware package that reads data from the Liebert FS is available. The data is stored and then can be transmitted through an RS-232 port, over a LAN (Local Area Network) or over the Internet, enabling a diagnostic reporting capability.

Versatile Interface Board (VIB)

An optional software and hardware package is available that allows for remote monitoring and control; via isolated auxiliary contacts:

Monitored Information

- OFF Mode
- STARTUP Mode
- CHARGE Mode
- State of Charge (SOC) = 0%
- State of Charge (SOC) = 12.5%
- State of Charge (SOC) = 25%
- State of Charge (SOC) = 37.5%
- State of Charge (SOC) = 50%
- State of Charge (SOC) = 62.5%
- State of Charge (SOC) = 75%
- State of Charge (SOC) = 87.5%
- Full Charge (SOC) = 100%
- DISCHARGE Mode
- SHUTDOWN Mode
- WARNING Mode
- FAULT mode
- Rotor Hot Standby

Control Commands

- Startup
- Shutdown
- Clear Fault

5.1.5 UPS Interconnection Kit

The UPS Interconnection Kit (IKIT) is a module of the Liebert FS that simplifies the interconnection to a UPS system. There are different versions of the IKIT available that have been specifically developed for the UPS systems the Liebert FS can integrate with. The Liebert FS in the standard configuration is delivered with an IKIT consisting of a fused Power Terminal Block for connection of the Positive and Negative terminals coming from the UPS DC bus or from an external disconnect switch.

5.1.6 Power Conversion Module

Power Conversion Module Controller (PCMC)

The Power Conversion Module Controller is located within the Power Conversion Module. The PCMC uses microprocessor-controlled logic to control the six pulse IGBT solid state switches and monitor the active magnetic levitation system.

These operations are firmware controlled eliminating the need for manual adjustments. The logic includes a self-test and diagnostic circuitry to identify any faults. Diagnostics are performed via a PC through the RS232 communication port or through the control panel located on the front of the Liebert FS.

IGBT Power Conversion Module (PCM)

The PCMC provides the overall control of the Liebert FS as well as the specific control for the synchronous reluctance motor generator via the IGBT solid-state switches within the Power Conversion Module.

The Power Conversion Module is a bi-directional system capable of sourcing or sinking power to and from the stator. It converts variable frequency, variable voltage from the stator and delivers a constant voltage DC output. Conversely, it converts DC power from the UPS System DC Bus to variable frequency, variable voltage output to the stator as directed by the PCMC to increase the speed of the synchronous reluctance motor-generator.

When delivering DC power, the output of the synchronous reluctance generator is rectified to DC by passing the high frequency AC current through a solid-state power conversion device. The DC output voltage of the Liebert FS has less than 2% Vrms ripple.

The voltage and frequency are adjusted using Pulse Width Modulation. The IGBT switches operate at a frequency of 18 kHz to produce the smooth sinusoidal current waveform to and from the motor generator. This is smoothed out further using an inductive and capacitive filter.

5.1.7 Magnetic Levitation Module (MLM)

The Magnetic Levitation Module provides control of the active magnetic levitation hardware.

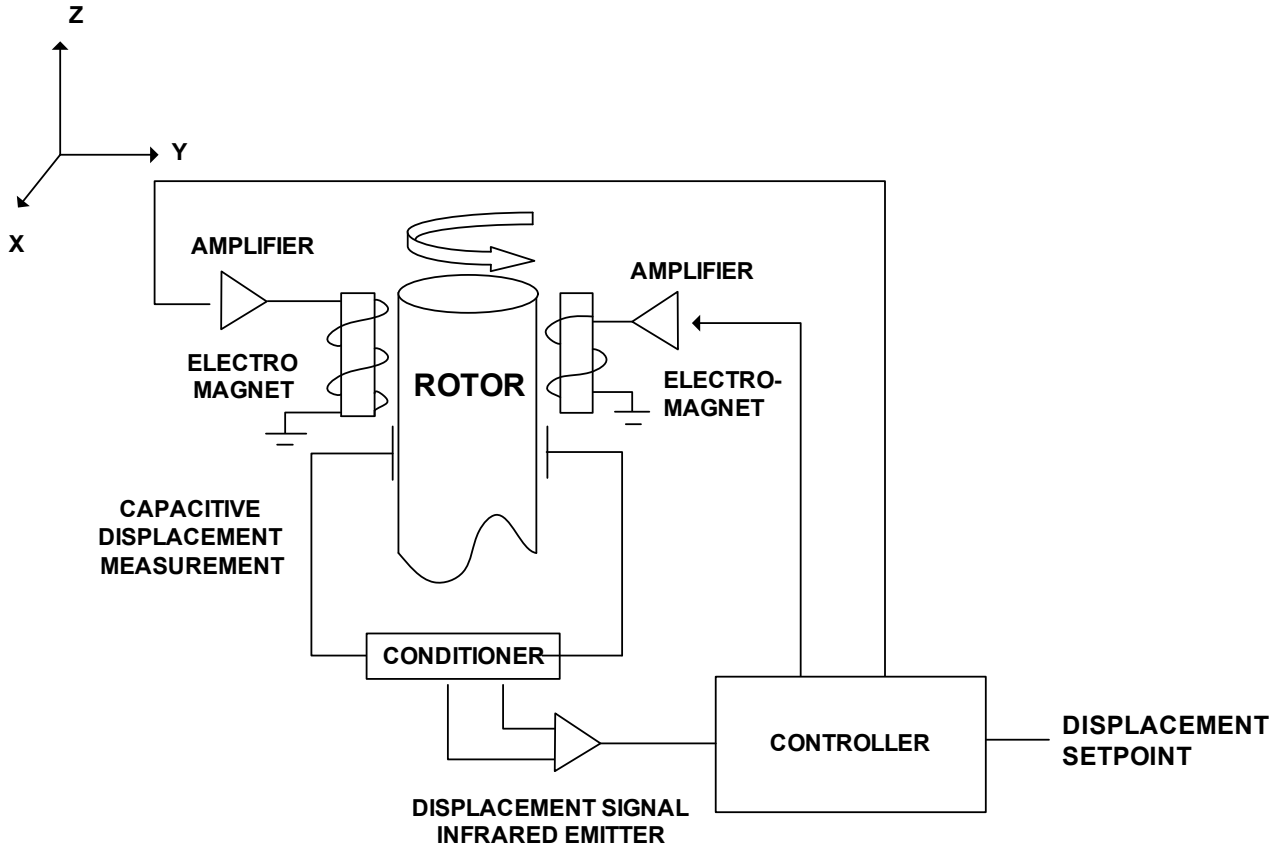
The Liebert FS has a unique active magnetic levitation system that fully levitates the flywheel-rotating group, allowing the flywheel to rotate without any physical contact. This has a number of advantages over mechanical bearing systems:

- Reduced drag- Mechanical bearings have a drag that is proportional to the square of the speed. The levitation system developed by Liebert uses the same power regardless of speed.
- Reliability and zero maintenance- The levitation system ensures there is no contact between the rotating parts and the housing and therefore there are no components to wear out. This ensures the unit will operate maintenance free for the life of the system.

The levitation system, works by measuring the displacement using a capacitive sensor, if the distance needs to be adjusted; the current to the electromagnet is altered to change the displacement, each axis is measured and controlled separately with its own capacitive sensor, electromagnet and feedback loop which, is controlled by the MLM. This is all done using analog control so it is very fast acting and reliable. There are 5 different circuits working independently, these are: Radial: Upper X, Y; Lower X, Y and Axial: Z Only

The principle of operation is the same in each case. The upper radial Y-axis is shown in **Figure 37**.

Figure 37 Schematic of the levitation system



Active Magnetic Levitation Hardware

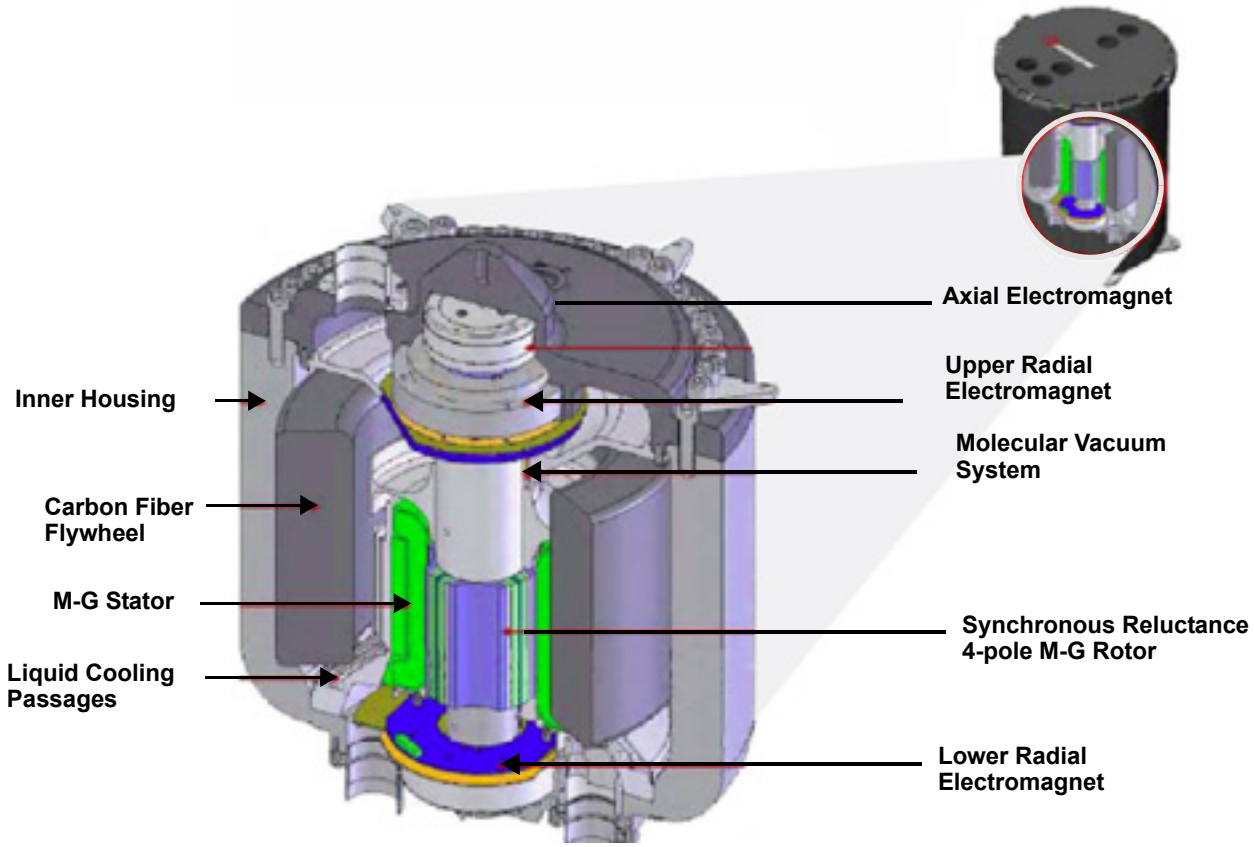
The electromagnets and capacitive displacement sensors that provide the active magnetic levitation are located within the flywheel module. See **5.1.7 - Magnetic Levitation Module (MLM)** for a full description of their operation.

5.1.8 Flywheel Module

The Flywheel Module houses several major components:

- The Rotating Group (high-speed carbon composite flywheel, high-speed shaft and rotor of the Motor-Generator)
- The Motor-Generator (synchronous reluctance technology)
- The Molecular Vacuum Pump
- Flywheel Sensors
- Active Magnetic Levitation Hardware
- Safety System

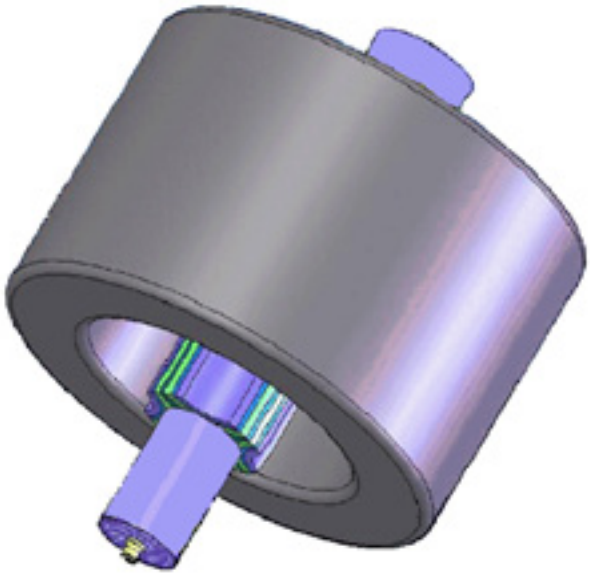
Figure 38 Liebert FS flywheel module



5.1.9 Rotor/Flywheel—Rotating Group

The flywheel is made of carbon/glass composite. This is mounted on a metal shaft with integral motor-rotor and together these components form the rotating group. The rotating group is magnetically levitated and centered so that it does not touch any other part while in normal operation.

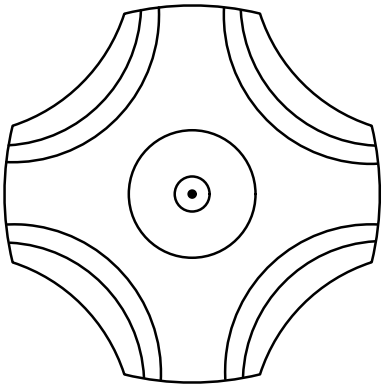
Figure 39 Rotating group



5.1.10 Motor Generator

The rotor is positioned within the stator in such a way that the rotor and stator provide the motor-generator function of the Liebert FS. The stator is liquid cooled and operates within a housing in which air has been evacuated. Together the stator and rotor operate as a synchronous reluctance motor-generator produces enough power for the system to supply its own internal demand and to supply to the output DC bus up to the rated power. The illustration in **Figure 40** shows the four poles of the synchronous reluctance machine.

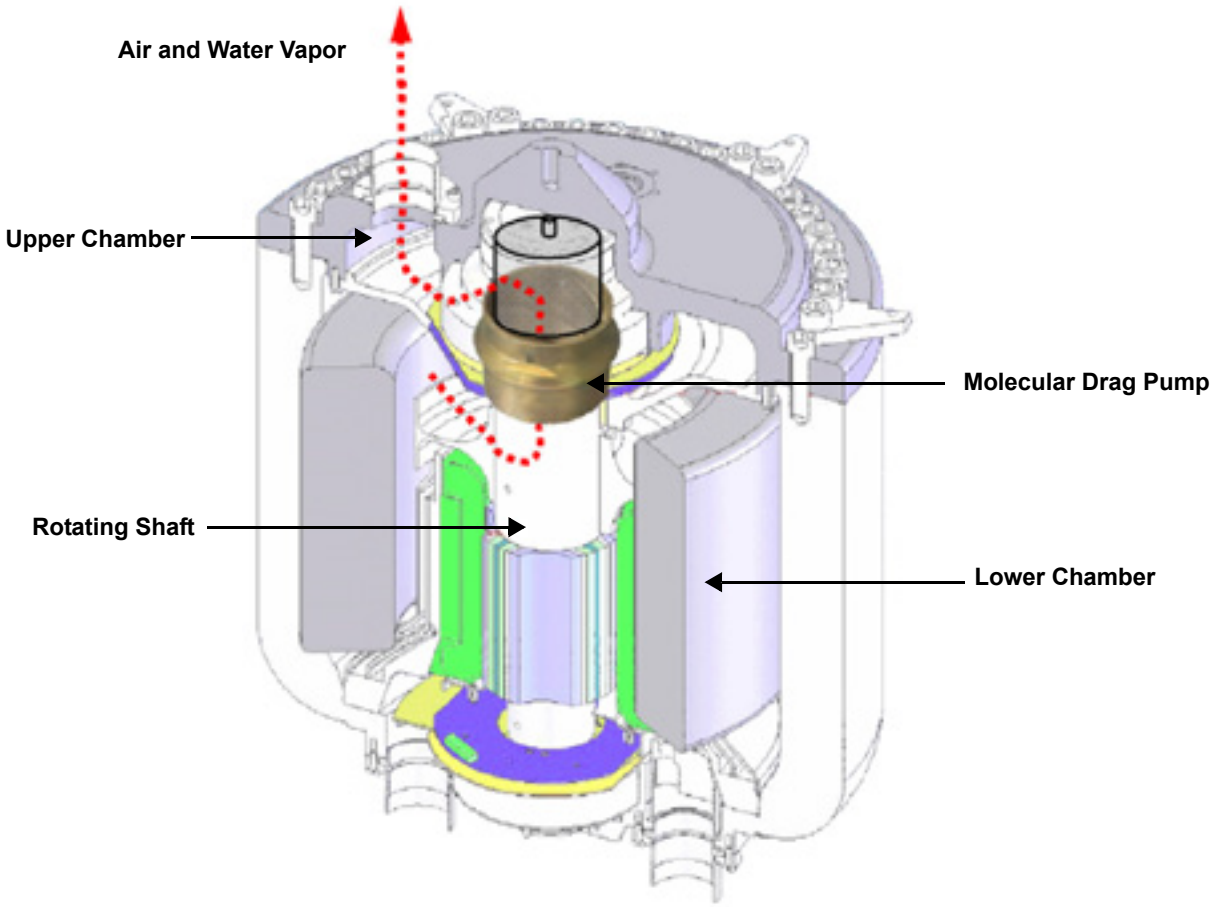
Figure 40 Cross-section of the synchronous reluctance motor rotor



5.1.11 Vacuum System

During manufacture, the vacuum chambers are evacuated and baked to remove water vapor. The vacuum system is then permanently sealed off to prevent any air entering the system and to remove the possibility of accidental loss of vacuum. The Liebert FS does not require an external vacuum pump to maintain a suitable vacuum level; the vacuum system instead relies on absorbers to maintain a rough vacuum within the upper chamber. A zero-maintenance molecular drag pump acts with the flywheel shaft to maintain a high-vacuum in the lower chamber, as shown in **Figure 41**. Vacuum levels of much less than 100 microTorr (10-7 atmosphere) are maintained in the lower chamber. The absorber material only needs to be recharged or changed, once every 15 years.

Figure 41 Vacuum system operation



5.1.12 Flywheel Sensors

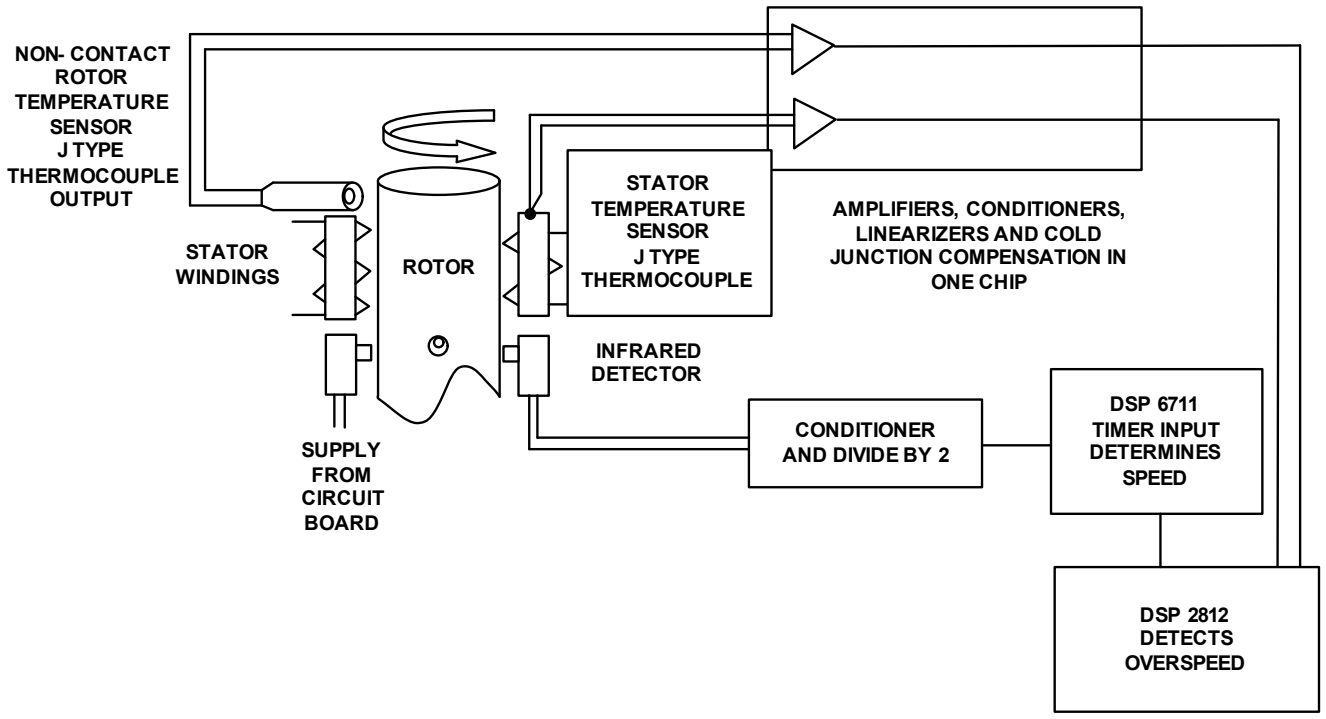
Speed

The speed detection system uses an infrared emitter and a sensor to detect the rotation of the shaft. A hole drilled through the shaft allows light to pass and is detected on the opposite side by an infrared detector. This signal is used to detect the rotor angle, the speed and any over speed condition. The pulsed signal passes into the 6711 DSP to be converted into a speed signal. This is then passed to the 2812 DSP. The 2812 checks for over-speed and shuts down the power electronics if this occurs. If either of the processors lock-up, the rotor will slow down, this guarantees that on over-speed cannot occur.

Temperature

The stator and rotor temperature detectors are thermocouples and are both conditioned in a similar way. The stator sensor is a Type J thermocouple potted into the stator windings. The rotor sensor is a non-contact type sensor that detects the temperature of the rotor surface and gives an output in a Type J thermocouple format.

Figure 42 Schematic for the speed and temperature sensors



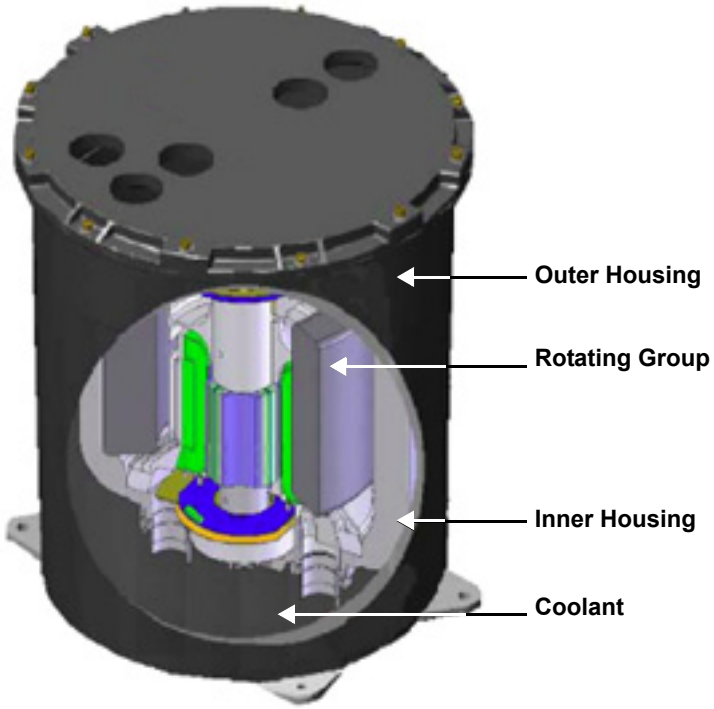
5.1.13 System Safety

Every composite flywheel is inspected, spin balanced and tested to 110% over-speed in accordance with NEMA guidelines. A patented dual-wall safety system ensures that in the unlikely event a flywheel were to separate during operation, the inner housing would retain the carbon fiber. As the carbon fiber separates, it will expand and transfer its torque to the inner housing. The inner housing is then allowed to rotate inside the outer housing. The cooling fluid in the outer housing, which surrounds the inner housing acts as a dynamic brake. The stored energy is released in a controlled manner as the flywheel / inner housing comes to a rest. The outer housing holds the entire safety system and acts as a reservoir for the cooling fluid

The Liebert FS has been previously tested under the following fault conditions with no adverse safety effects:

- Motor-generator AC short circuit
- DC short circuit
- Power Conversion Module failure
- Magnetic Levitation System failure
- Composite rotor failure
- Motor Rotor Failure
- Loss of Vacuum

Figure 43 Cutaway flywheel module



5.1.14 Cabinet

The Liebert FS is a compact design housed in a free-standing cabinet with a NEMA 1 construction rating or IEC equivalent. No space is required between the back or sides of the cabinet and any walls. The front clearance of 36" per the National Electrical Code is required. The Liebert FS accommodates top (standard) and side entry cables. The Liebert FS can be rolled into place and go through standard doors.

5.1.15 Ventilation and Cooling

The Liebert FS stator and power electronics are liquid cooled with a liquid-to-air radiator. The radiator within the Liebert FS package is designed for natural and forced air-cooling. Air inlets are provided from the bottom front of the Liebert FS enclosure. Air exhaust is from the top of the unit. Air filters are provided as an option. A minimum 12" clearance overhead is required for the exhaust airflow.

The Liebert FS was designed with reliability in mind, the radiator is positioned to take advantage of natural cooling and forced-air is only used when there is an elevated temperature. This also applies to the circulating pump for the coolant, which is a highly reliable magnetically coupled centrifugal pump that is powered with a brushless DC motor. This pump operates only when there is an elevated temperature within the stator or the PCM, this extends the life of the pump to the point that it will continue to operate over the life of the unit.

5.2 List of System User-Configurable Parameters

In order to support a wide set of UPS integrations, the Liebert FS can be configured using the following operating parameters: See **6.0 - Operation** for more information on these parameters and instructions on system setup and entering parameters to system.

Charge Voltage (Vcharge)

Vcharge is the voltage threshold above which the Liebert FS begins to charge/recharge.

Vcharge must be set at least 10VDC greater than Vreg.

- Range: 360-600VDC
- Default setting: 530VDC

Regulation Voltage (Vreg)

- Vreg is the voltage setpoint at which the Liebert FS will regulate the DC bus voltage in Discharge Mode
- Vreg must be set at least 10 VDC less than Vcharge.
- Range: 350-590VDC
- Default setting: 520VDC

Maximum Charge Current (Max Charge Current)

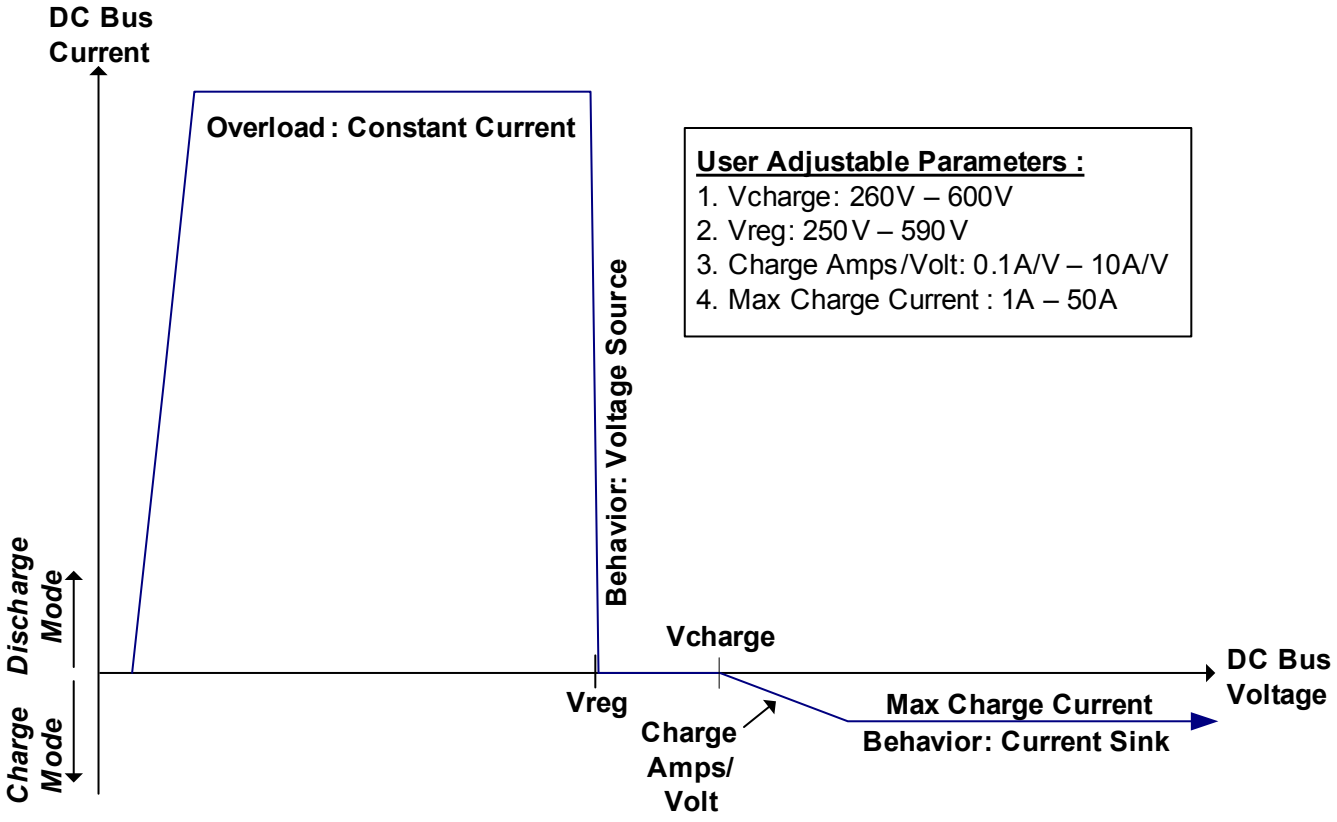
- Max Charge Current is the Maximum Current the Liebert FS is allowed to draw from the UPS DC bus.
- Range—1-50A (typical operation requires a minimum of 3A or 5A)
- Default setting—20 A

Charge Conductance (Charge Amps/Volts)

Charge amps/volts is used to set the Liebert FS charging current drawn from the UPS DC bus based upon how much the UPS DC bus voltage is above Vcharge and so without exceeding the Max Charge Current.

- Range—0.1-10 A/V
- Default setting: 2 A/V

Figure 44 Voltage and Inductance curve



The V-I (Voltage and Inductance) curve (see **Figure 44**) shows the performance characteristics and modes of operation of the Liebert FS system based on the seven user-configurable system parameters.

Regulation Voltage Delta During Discharge (Vreg Delta 1)

Vreg Delta is the programmed amount of voltage drop from the beginning of discharge (SOC = 100%) to the Vreg Delta TSOC.

- Range—from 0 to (Vreg - 250) VDC
  (Ex: if Vreg = 500, then the Vreg Delta1 can be set between 0 and 250 VDC)
- Default setting—0 VDC

Regulation Voltage Delta Transition at State of Charge (Vreg Delta T SOC)

- Range—0-100%
- Default setting—0

Regulation Voltage Delta During Discharge (Vreg Delta 2)

Vreg Delta 2 is the programmed amount of voltage drop from the Transition State of Charge to the end of discharge (T SOC to the end of discharge (SOC = 0%)

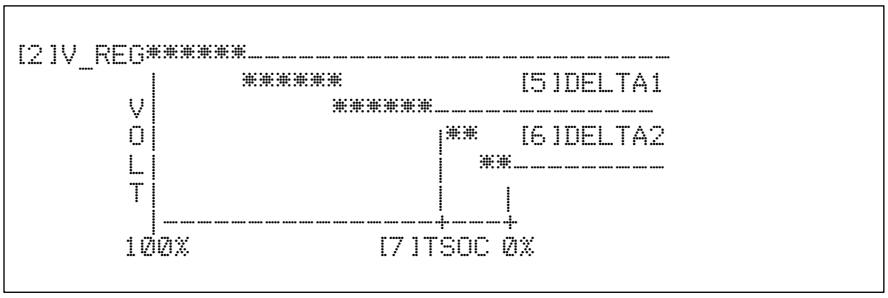
- Range—From 0 to (Vreg - Vreg Delta1) VDC
  (Ex: if Vreg = 500, and Vreg Delta1 = 50, Vreg Delta2 can be set between 0 and 200 VDC)
- Default setting—0VDC

NOTE

Programming of Regulation Voltage (Vreg) Delta User Configurable Parameters

- *During a discharge the regulation voltage (Vreg) can be adjusted by setting the three parameter set points described above; Vreg Delta 1, the Transition State of Charge (T SOC) and Vreg Delta 2. (For more information on programming these parameters from the Control Panel see **6.4.1 - Screen Tree Menu Functions**)*
- *The Liebert FS allows for programming two different discharge slopes (Vreg Delta1 and Vreg Delta2) and enabling a soft "handcuff" or transition before end of discharge. (Ex: if T SOC = 20 then transition from Vreg Delta 1 to Vreg Delta 2 will take place when 80%, (Vreg TSOC), of the stored energy has been discharged, see **Figure 45**).*
- *Vreg Delta1 is used to program an initial slope from beginning of discharge to Vreg TSOC over which the regulated voltage value will decrease and at which point a transition will automatically occur to the secondary slope to 0% SOC at the Vreg Delta2 setpoint.*

Figure 45 Vreg delta help screen



5.3 Modes of Operation

The Liebert FS consists of a variety of operational modes. Each mode is based on a set of programmed conditions. The Control Panel indicates the current mode and the status of that mode. Function keys are enabled or disabled depending on the mode and status.

The Liebert FS modes are:

- OFF
- STANDBY
- STARTUP
- CHARGE
- READY
- DISCHARGE
- SHUTDOWN
- COAST
- FAULT

The Liebert FS is programmed to operate in a variety of conditional modes. The modes and status for each mode will be indicated on the control panel. The Liebert FS is set up to transition through the various modes with no or minimal user intervention.

5.3.1 OFF Mode

When the Liebert FS is initially powered on, it enters the OFF mode and magnetically levitates its rotating group. A manual user command will make the system transition from OFF mode to STARTUP mode if all startup conditions are met.

NOTE

Startup conditions are:

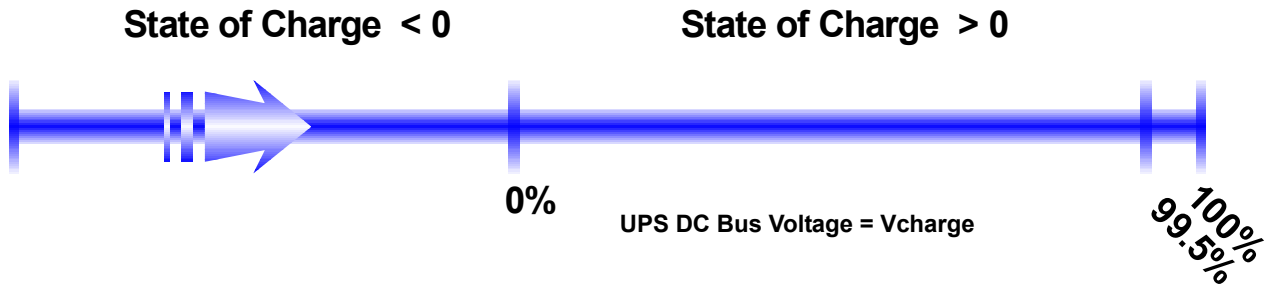
- *UPS DC bus voltage ≥ Vcharge and*
- *Status is "OK".*

The Liebert FS also will enter OFF mode at the end of a shutdown and will transition automatically from SHUTDOWN mode to OFF mode.

5.3.2 STANDBY Mode

In STANDBY Mode, the Liebert FS will be ready for Startup but be in a STANDBY Mode waiting for user initiation of STARTUP Mode (State of Charge = 0%). By pressing the STARTUP button "F1" at that point the Liebert FS will automatically transition into STARTUP Mode.

Figure 46 STANDBY mode diagram



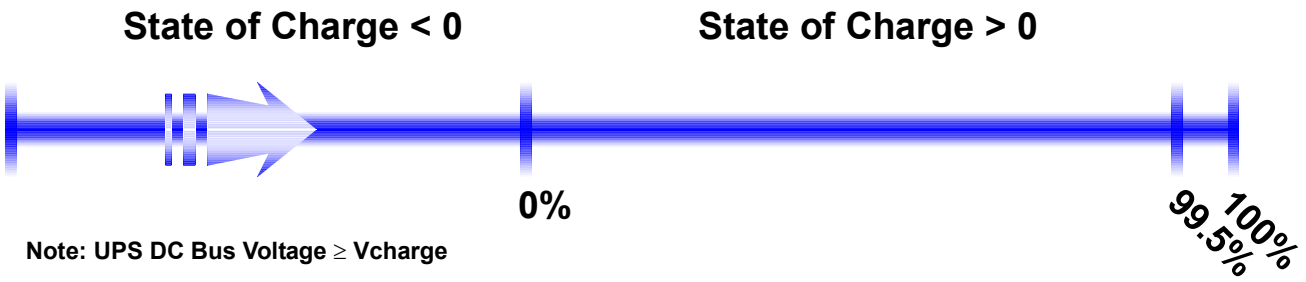
The Liebert FS will be in STANDBY Mode as long as:

- Liebert FS's SOC is less than 0%; and
- UPS DC Bus Voltage = Vcharge
- STARTUP has not been initiated

5.3.3 STARTUP Mode

In STARTUP mode, the Liebert FS will charge (increase flywheel speed) up to the minimum operating speed (State of Charge = 0%). At that point the Liebert FS will automatically transition into CHARGE mode.

Figure 47 Startup mode diagram



Note: UPS DC Bus Voltage ≥ Vcharge

The Liebert FS will be in STARTUP mode as long as:

- Liebert FS's SOC is less than 0% and
- UPS DC Bus Voltage ≥ Vcharge.

NOTE

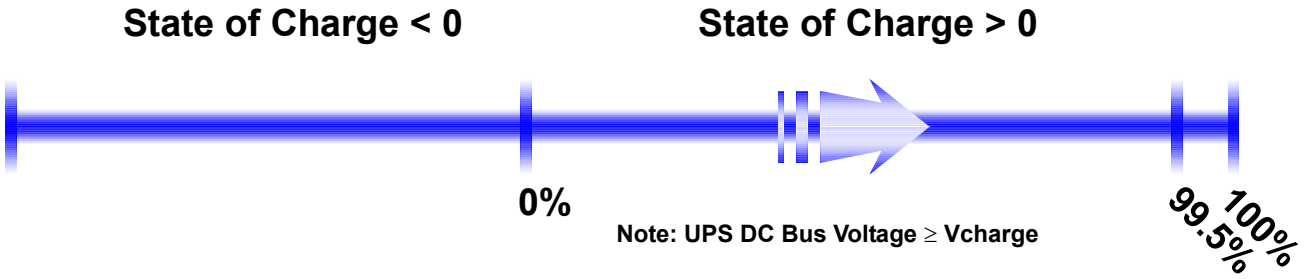
In STARTUP mode, the Liebert FS will not be capable of supporting the UPS DC bus.

In case the UPS DC bus voltage drops below Vcharge while in STARTUP mode, the Liebert FS will transition automatically into COAST mode. As soon as the UPS DC bus voltage rises above Vcharge, the Liebert FS automatically exits COAST mode and resumes STARTUP mode.

5.3.4 CHARGE Mode

To charge the Liebert FS, the Liebert FS will draw power from the UPS DC bus to accelerate the flywheel (as long as the UPS DC bus voltage is higher than Vcharge). In this mode, the Liebert FS State of Charge (SOC) will progressively increase from 0% to 100%.

Figure 48 CHARGE mode diagram



The Liebert FS will be in CHARGE mode as long as:

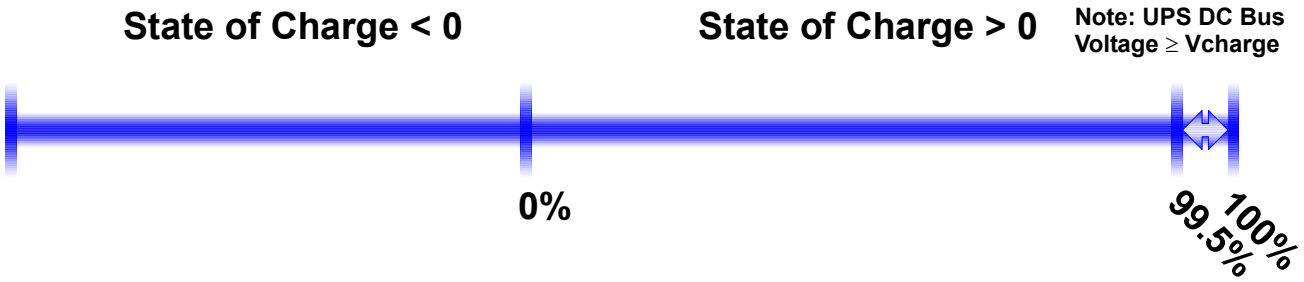
- Liebert FS's SOC is between 0% and 100% and
- UPS DC Bus Voltage ≥ Vcharge.

NOTE
While in CHARGE mode, the Liebert FS will be capable of supporting the UPS DC bus.

5.3.5 READY Mode

When the SOC reaches 100%, the unit will automatically transition into the READY mode. This is the mode in which the Liebert FS will spend most of its operating time. In this mode, the Liebert FS maintains its State Of Charge greater than 99.5%. The Liebert FS's SOC will be allowed to drift down to SOC = 99.5%, at which point it will transition back into CHARGE mode and charge back up to READY mode and SOC = 100%. During normal operation, the Liebert FS will continue to automatically transition between the READY and CHARGE modes to maintain a SOC between 99.5 and 100% until either a DISCHARGE or SHUTDOWN is initiated.

Figure 49 READY mode diagram



The Liebert FS will be in READY mode as long as:

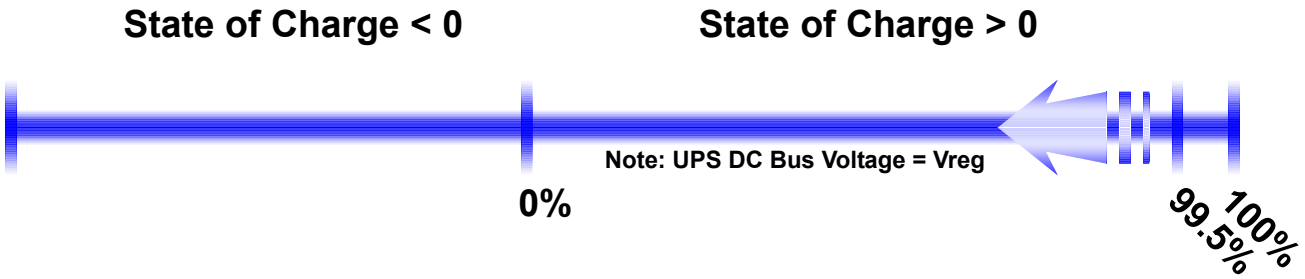
- Liebert FS's SOC is between 99.5% and 100% and
- UPS DC Bus Voltage ≥ Vcharge.

NOTE
While in READY mode—just as in CHARGE mode—the Liebert FS will be capable of supporting the UPS DC bus.

5.3.6 DISCHARGE Mode

Starting from either CHARGE or READY mode, the Liebert FS will enter the DISCHARGE mode if the UPS DC Bus Voltage goes below Vcharge. In DISCHARGE mode, the Liebert FS will regulate the DC bus at Vreg.

Figure 50 DISCHARGE mode diagram



The Liebert FS will be in DISCHARGE mode as long as:

- UPS DC Bus Voltage < Vcharge and
- Liebert FS's SOC is more than 0%.

The Liebert FS will leave the DISCHARGE mode and transition into CHARGE mode if the UPS DC bus recovers (UPS DC Bus Voltage = Vcharge) before the Liebert FS's SOC reaches 0%. In case the UPS DC bus doesn't recover before the Liebert FS's SOC reaches 0%, the Liebert FS will transition into SHUTDOWN mode.

5.3.7 SHUTDOWN Mode

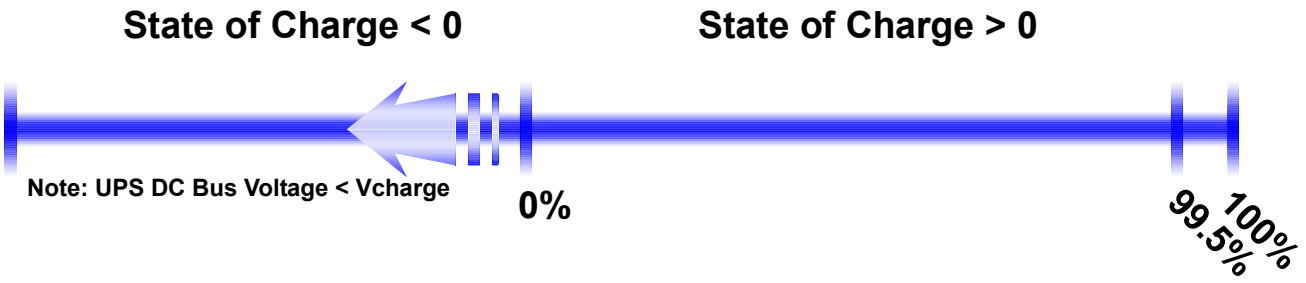
In SHUTDOWN mode, the flywheel will actively spin down.

There are two ways the Liebert FS can transition into SHUTDOWN mode, by a complete discharge and by a user command.

Following a Liebert FS Discharge Down to SOC = 0%

This is the most common SHUTDOWN process. This occurs when the Liebert FS's SOC drops below 0% and the UPS System DC Bus voltage is less than Vcharge. If the Liebert FS entered the SHUTDOWN mode after leaving DISCHARGE mode, the Liebert FS will automatically transition into STARTUP mode provided the UPS System DC Bus voltage returns to a value greater than Vcharge (i.e., when the electric grid returns or the standby generator supplies power to the UPS).

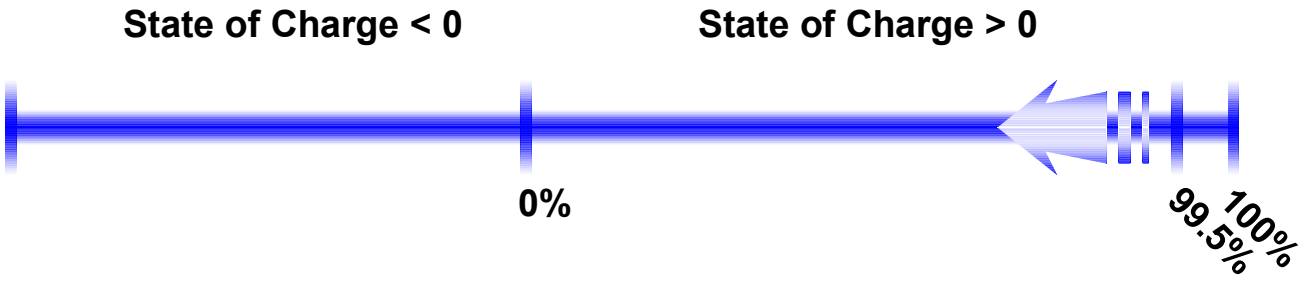
Figure 51 SHUTDOWN mode diagram - shutdown after full discharge



Following a User Command

In any mode, except OFF mode, the user may command the Liebert FS to transition in SHUTDOWN. While in SHUTDOWN mode, the user will still be able to command the Liebert FS to transition into CHARGE mode (if SOC > 0%) or STARTUP mode (if SOC < 0%), provided that the UPS System DC bus voltage is greater than Vcharge.

Figure 52 SHUTDOWN mode diagram - user-initiated shutdown



5.3.8 COAST Mode

A transition into COAST mode can occur when the UPS System DC Bus voltage drops below Vcharge while the Liebert FS is in STARTUP mode. While in COAST mode, the Liebert FS is in an idling condition where it neither draws nor generates any power.

As soon as the UPS DC Bus Voltage rises above Vcharge, the Liebert FS will automatically exit COAST mode and resume STARTUP mode.

After five minutes in COAST Mode, if the UPS DC Bus voltage has not risen above Vcharge, the Liebert FS will automatically transition into SHUTDOWN Mode.

5.3.9 FAULT Mode

The Liebert FS includes self-test and diagnostic circuitry such that most systems malfunctions can be identified. In case of a system malfunction, the Liebert FS will transition into FAULT mode.

While in FAULT mode, the Liebert FS is disabled—all power electronics are turned off. Most faults are cleared automatically by the system without the need for user intervention. Some faults do require user action to clear the fault or to notify Liebert Services. Refer to the **8.0 - Troubleshooting** for more information).

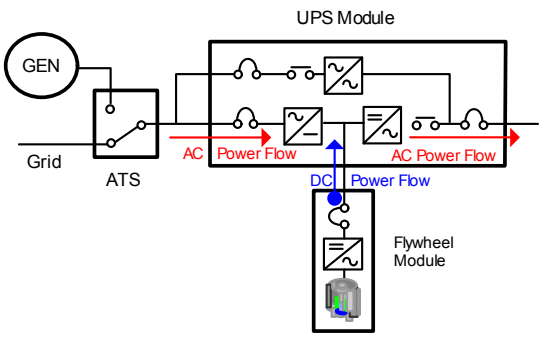
NOTE
*Depending on the nature of the fault, the Liebert FS may still be capable of supporting the UPS DC bus. Refer to **8.0 - Troubleshooting** for more information.*

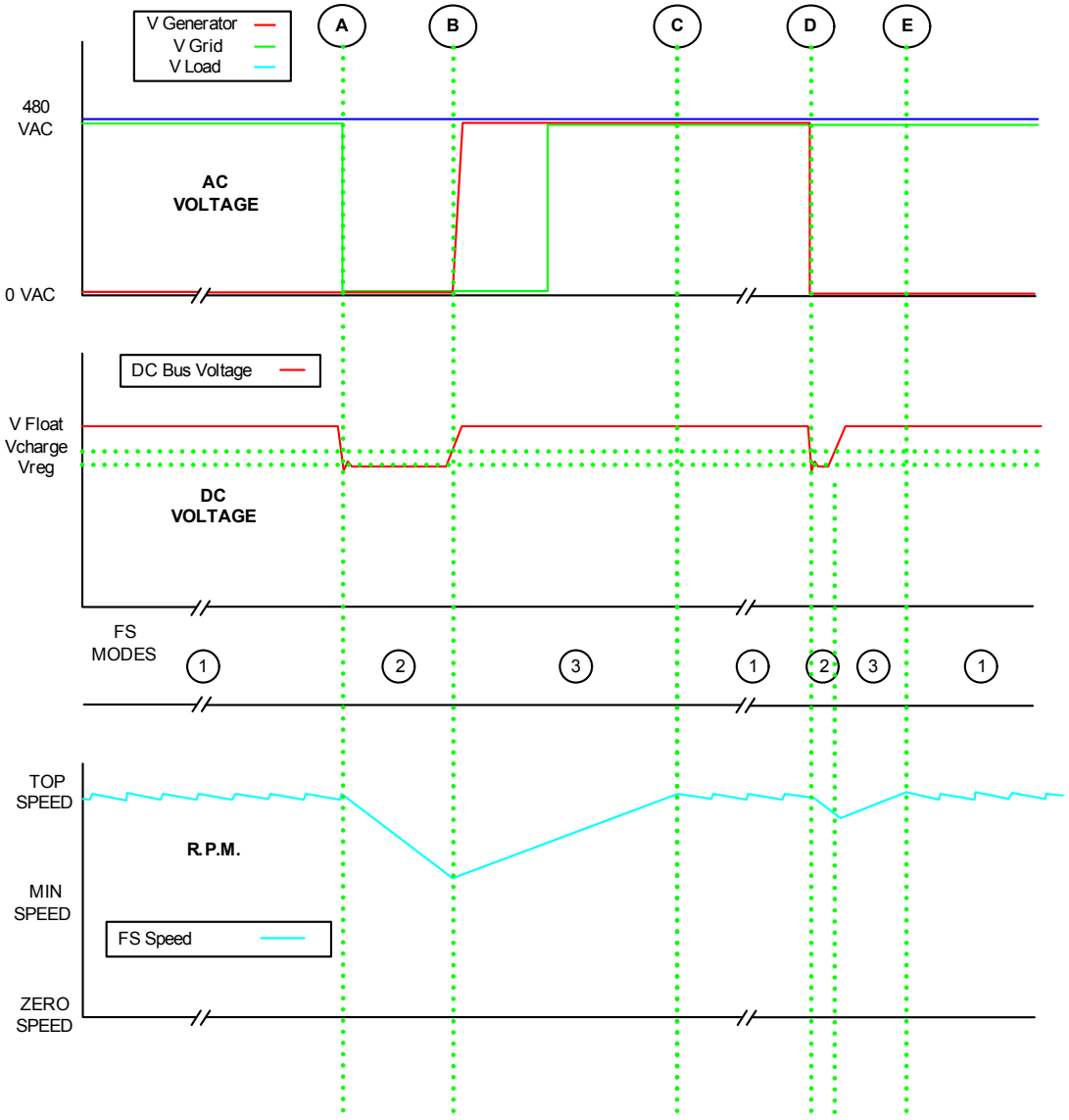
The Liebert FS is programmed to operate in a variety of conditional modes. The modes and status for each mode will be indicated on the control panel. The Liebert FS is set up to transition through the various modes with no or minimal user intervention. **Figure 53** illustrates the various modes of operation.

Figure 53 Typical operation modes

KEY #	MODE	DESCRIPTION
1	READY	Idle condition waiting for event
2	DISCHARGE	FS supporting the critical load
3	CHARGE	Charging to top speed

A	Grid Supply lost , FS supporting the load
B	Generator Starts , A.T.S. transfers the load
C	FS fully charged ready to support the load
D	FS supports the load as the A .T.S. transitions back to grid supply
E	FS fully charged ready to support the load





5.4 Maintenance and Reliability

The Liebert FS is designed to require minimal preventive servicing and maintenance. There are no user serviceable parts in the Liebert FS. Please contact a Liebert-Certified Technician before attempting to remove or service any components of the system. No bearings maintenance or replacement is required over the life of the Liebert FS under normal operation conditions. No vacuum pump maintenance or replacement is required over the life of the Liebert FS under normal operation conditions.

The optional inlet air filter in the cabinet will need to be replaced when it is sufficiently dirty as to reduce the flow of air into the cabinet. Ambient conditions at the installation site will determine the frequency of replacement. The Liebert FS Flywheel Module is designed for fifteen-year service life before first scheduled maintenance. At fifteen years, the vacuum absorbers should be replaced or regenerated.

The reliability of the Liebert FS power electronics is consistent with UPS power electronics of comparable energy levels. The mechanical assemblies are of higher life and reliability than other commercially available flywheel systems due to the elimination of rolling element bearings and external vacuum-pumping systems.

6.0 OPERATION

6.1 Operator Controls

The Liebert FS uses a Control Panel as the primary means for an operator to interface with the system. The Control Panel enables the operator to perform the following tasks:

Initial setup and adjustments to programmable parameters (access limited by Security Access function):

- Set the Liebert FS Control Parameters
- Configure Liebert FS for operation with external equipment

Initial setup and adjustments to Security Access functions

- Set pass codes and access levels

Execute operational procedures:

- Startup and shutdown of the Liebert FS.

Quick view of operational status:

- View current Mode of Operation
- View current Status

Access System Status reports:

- Check temperatures and voltages
- Check vital system health indicators

Access System History

- Check number of discharges
- Check for total hours of operation
- Check for warnings and faults history

Monitor the power flow between the Liebert FS and a UPS and other Liebert FS meter readings:

- Monitor power flow from Liebert FS to the UPS DC Bus or from UPS to the Liebert FS
- Monitor Liebert FS State of Charge
- Monitor DC Bus Voltage
- Determine if the critical load is being supplied power from the Liebert FS
- Monitor charging after discharge

6.2 Control Panel

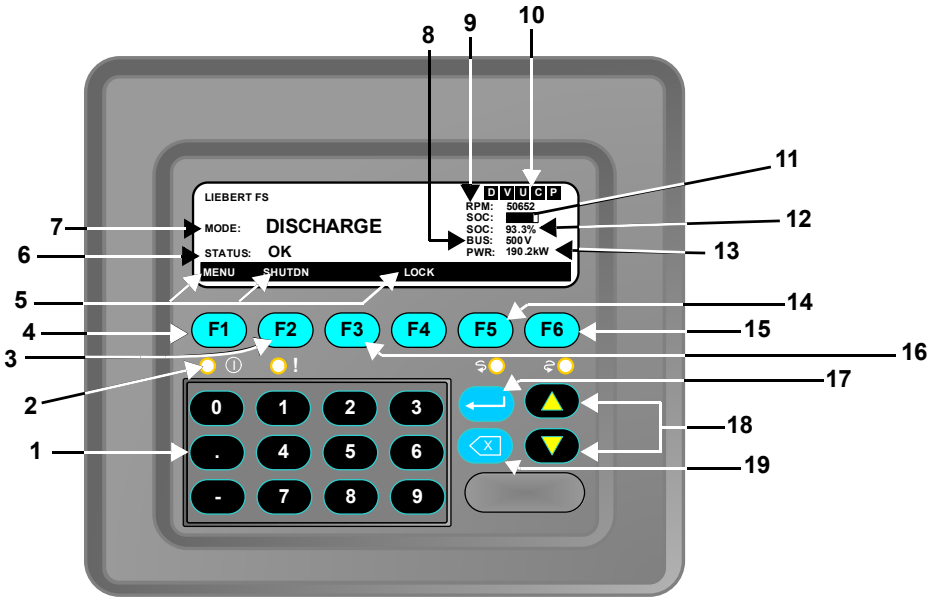
The Control Panel (see **Figure 54**) below represents the Control Panel on the Liebert FS. The diagram is labeled as a reference for the various keys, functions and data found on the Control Panel.

NOTE

*(The actual locations of status indicators on the Control Panel display, corresponding to the numbers below, may vary from **Figure 54** depending on software version.)*

Figure 54 Control panel view

See Table 4 for keyboard layout



NOTE

The control panel view is for reference only. Not all items will be enabled and visible on the screen at the same time during operation

Navigating the control panel is a simple process that involves responses to user prompts displayed in the control panel. Using the panel to operate the unit will be described further in this section.

Table 4 Control panel keyboard layout (refer to Figure 54)

Keyboard Location	Operation / Navigation Keys	Keyboard Location	Screen Indication Keys
1	Numerical Keypad	11	SOC: State of Charge Bar
2	LEDs used for Servicing	12	SOC: State of Charge Value
3	F2 Shutdown key - Main Screen	13	PWR: Bus Power
4	F1 Start Up key - Main Screen	14	F5 More Information key - Fault Screen
5	Soft Menus	15	F6 Menu key - Main Screen
6	STATUS: System status (see **6.2.3 - System STATUS Indicators**)	16	F3 Clear Fault key - Fault Screen
7	MODE: System mode (see **6.2.2 - System MODE Indicators**)	17	Enter key
8	BUS: Internal DC Bus Voltage	18	Scroll Up and Down keys
9	RPM: Flywheel Rotation Speed	19	Backspace
10	Power and Options: On/Off		

6.2.1 Main screen function descriptions

Figures 55 and **56**. provide descriptions and locations of the information and functions available from the Main screen and the Fault Screen.

Figure 55 Main screen functions

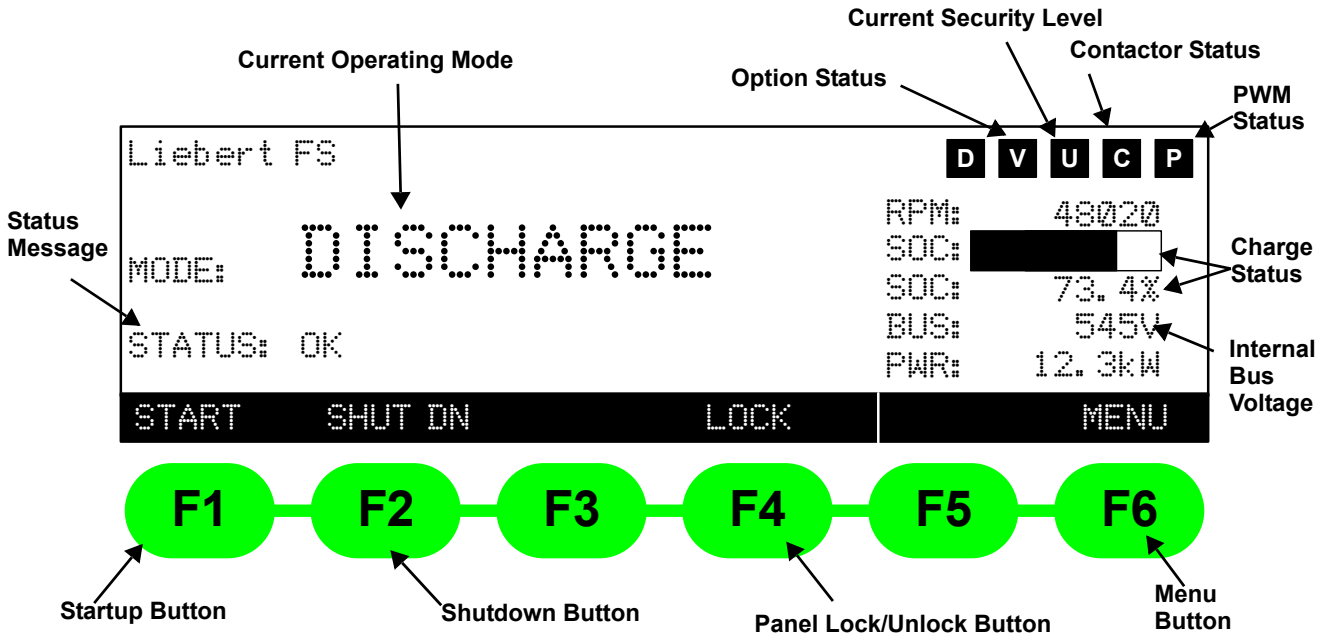
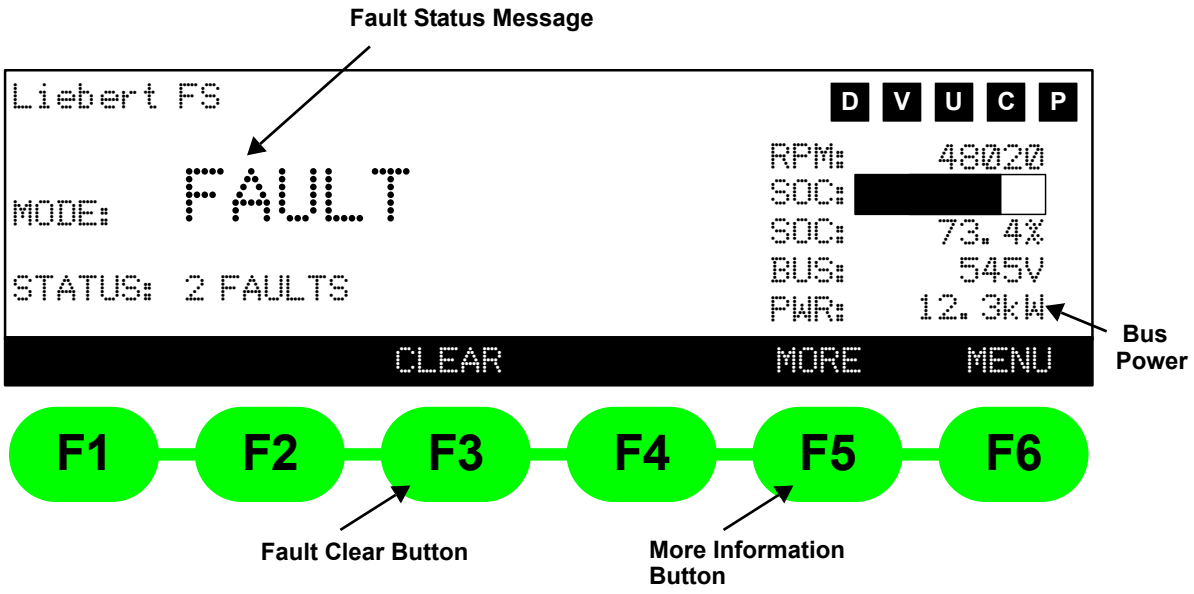


Figure 56 Fault screen functions



6.2.2 System MODE Indicators

The Liebert FS has nine modes of operation: OFF, STARTUP, CHARGE, READY, DISCHARGE, SHUTDOWN, COAST, FAULT and STANDBY. These are displayed on the main screen of the control panel as identified in **Figure 55**. **Table 5** lists the system Modes along with the corresponding Contactor Status, and the Conditions required to operate in these Modes: external voltage range, speed and command.

NOTE:
*See **5.3 - Modes of Operation** for further details on modes of operation.*

Table 5 Operation modes

Mode	Contactor	Condition		
		External Voltage	Speed	Command
OFF	Open	Vext < Vchg	0 ~ 3500	—
STANDBY	Open	Vext > Vchg	0 ~ 200	—
STARTUP	Close	Vext > Vchg	200 ~ Min Speed	STARTUP
CHARGE	Close	Vext > Vchg	Min Speed ~ Max Speed	STARTUP
READY	Close	Vext > Vchg	Max Speed ~ Max Speed + 200	STARTUP
DISCHARGE	Close	Vext < Vchg	Min Speed ~ Max Speed	STARTUP
COAST	Close	330 < Vext < Vchg	200 ~ Min Speed	STARTUP
SHUTDOWN	Open	Vext < 330	200 ~ Min Speed	STARTUP
	Open	Any	Min Speed ~ Max Speed	SHUTDOWN
	Close	Vext > 330	200 ~ Min Speed	SHUTDOWN
FAULT	Open	Any	0 ~ Max Speed	—
STANDBY	—	After CLRFLT		

Min Speed: Minimum operating speed; State of Charge (SOC) will be 0% at this speed.
Max Speed: Maximum operating speed; State of Charge (SOC) will be 100% at this speed.

6.2.3 System STATUS Indicators

The Liebert FS system displays multiple status conditions during operation. **Table 6** shows the complete list of status indicators for the Liebert FS and the corresponding condition.

Table 6 System status indicators

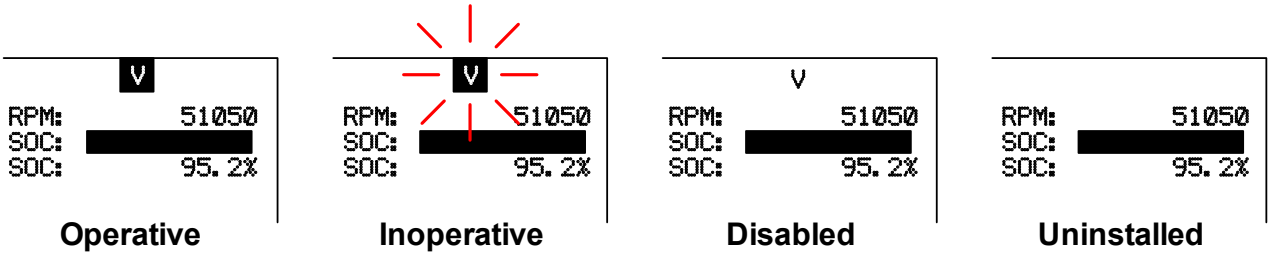
Message		Condition
1	OK	All systems operating normally.
2	READY	All systems operational and ready for startup.
3	APPLY 520*V	External voltage is less than the Charge Voltage*
4	n WARNINGS	Multiple warnings
5	n FAULTS	Multiple faults
6	OVERSPEED	Speed is higher than the Max Speed plus 200 RPM
7	TESTING VACUUM	Vacuum testing at 10000 RPM
8	OPENING CONTACTOR	Waiting until the current is stabilized
9	CLOSING CONTACTOR	Waiting until the voltages are stabilized
10	WAIT	Waiting until the voltages are stabilized

* Charge voltage is an adjustable user parameter; 520V is used only as an example.

6.2.4 Other Status Indicators

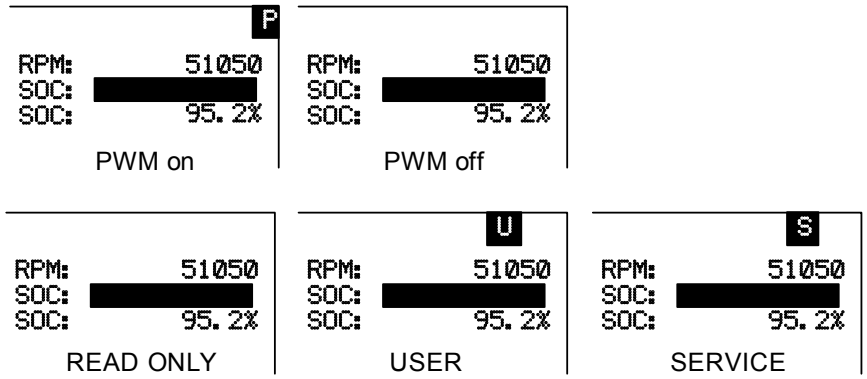
The Liebert FS system displays additional indicators during operation.

- Option Status; DCM or VIB (example: V abbreviation for VIB enabled



Default setting

- Security Levels



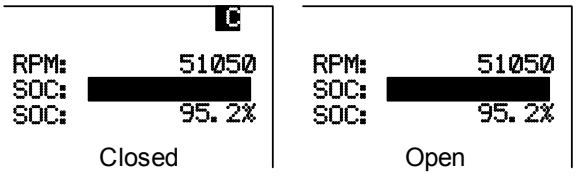
Default setting

- PWM: Pulse Width Modulation Status (ON or OFF)
- SOC: State of Charge (0-100%)

  SOC shows a relative energy stored in the system. SOC is determined with the following equation. It is 100% at Max Speed. A negative SOC means the required energy in % to get to the CHARGE state.

$$SOC = \frac{rpm^2 - MinRpm^2}{MaxRpm^2 - MinRpm^{2(2)}} \times 100$$

- Contactor Status



- LOCK/UNLOCK of the Control Panel

Control Panel can be locked or unlocked for security purposes. Locking or unlocking the display panel requires a user password to confirm. See **6.3.2 - Password**.

- PWR: Bus Power

  PWR shows the DC power transfer in kW. Positive power indicates DISCHARGE and negative power indicates CHARGE, respectively.

6.3 Security Access

6.3.1 Security Levels

The Liebert FS software has two security levels: READ-ONLY and USER. Security levels restrict access to system resources, such as EEPROM parameters, terminal commands and display panel functions. From the Main Screen, **Figure 55**, the display can be locked at any time to prevent use of Control Panel. Pressing F4 button under "LOCK" will prompt the user to enter a password to "LOCK" the system. Once locked F4 will now read "UNLOCK" and pressing this will prompt you to enter the Password to the system so that the user will be able to operate the Control Panel and adjust system parameters and settings.

6.3.2 Password

READ-ONLY level has no password and it is default level at reset.

The USER level password is user-configurable and saved in EEPROM. The default USER level password is "1234", and the password should be between 3 - 12 digits.

6.3.3 EPROM (System) Parameters

EEPROM (system) parameters can be accessed through display panel or terminal commands. They can be read and written through terminal or display panel, but accessible parameters are limited by security levels. The parameters for each level have different number range. Unused numbers are reserved for future usage.

Table 7 EEPROM parameter number ranges

Security Level	Parameter Number Range
Read-Only	0 ~ 99
User (Editable)	0 ~ 99

6.4 Menu Tree and Navigation

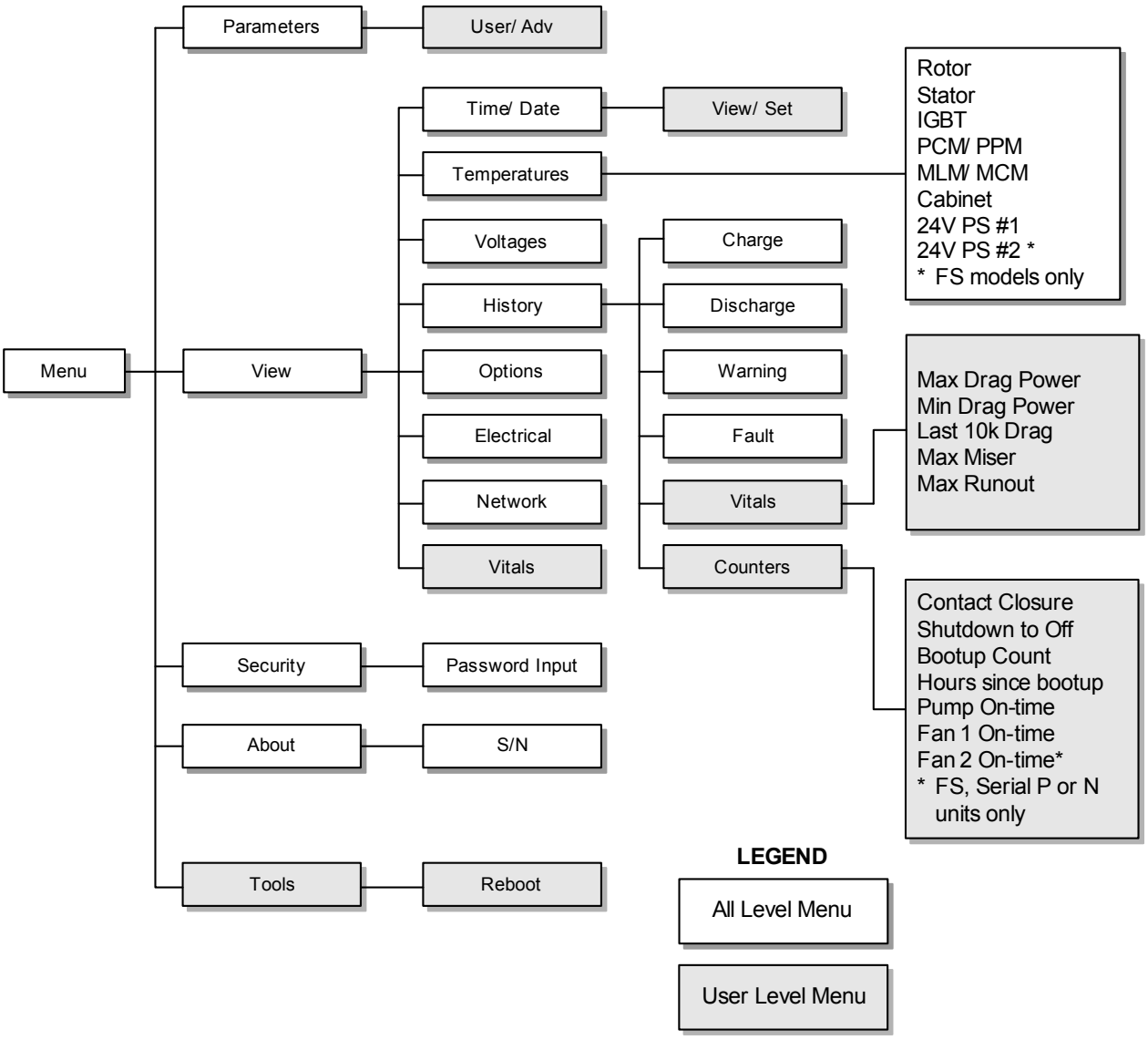
6.4.1 Screen Tree Menu Functions

The following diagram shows all of the screens accessible from the control panel and the path to bring up these screens. The screens are used for configuring the Liebert FS for operation and accessing data current and historical data on its performance. The screens are organized by five primary function areas; Parameters, View, Security, About, and Tools. These are displayed on the Main Menu screen. Some of the screens require User level or Service level passwords to access as shown in the legend below. Refer to **6.3 - Security Access** for more information on this subject.

Table 8 PCMC parameters, read-only and user (Liebert FS software)

No	Parameter Name	Unit	Default	Minimum	Maximum
1	Vcharge Setpoint	V	530	360	800
2	Vreg Setpoint	V	520	350	790
3	Icharge Max Setpoint	A	30	1	50
4	Amps per Volt Setpoint	A/V	20	1	50
5	Vreg Delta Setpoint 1	V	0	0	150
6	Vreg Delta Transition (SOC)	%	0	0	100
7	Vreg Delta Setpoint 2	V	0	0	150

Figure 57 Menu tree



6.4.2 Navigation and Operation of Control Panel

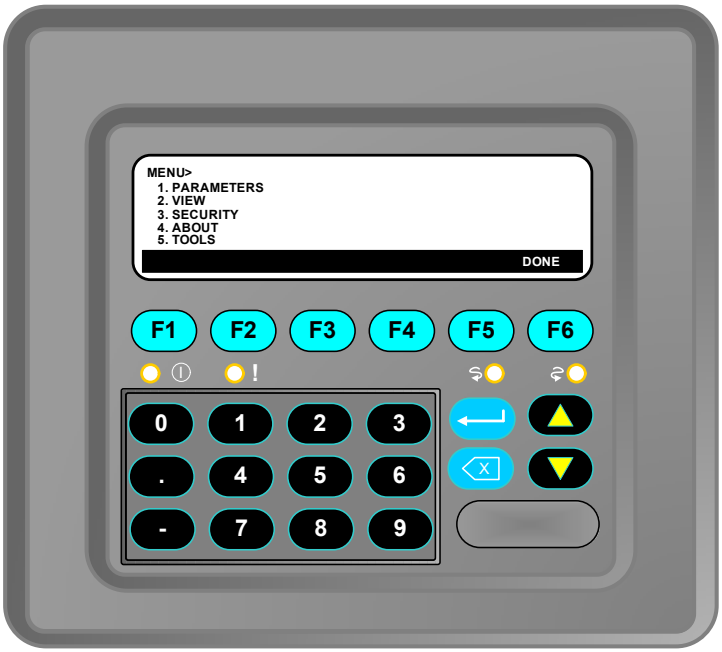
Navigation of the menu screens is simple and intuitive. From the Main Screen, also referred to as "Home", menu functions and screens can be accessed by using the function keys and the numeric keypad. The function keys, F1- F6, initiate certain system functions and Modes; STARTUP, SHUTDOWN and also perform certain menu screen functions; DONE, PREVIOUS, NEXT, and HOME. The up and down arrows on the control panel enable the user to scroll up or down certain menus. The numeric keypad can be used to enter values for system setup and the Enter and Backspace keys to enter numbers or backspace to change entry. Pressing F6 or DONE completes the entry process. Always double check by going back to the previous screen to verify the entry is complete and accurate.

To access the Main Menu press the F6 button below the "Menu" option in the lower right. When pressed, the "Menu" key, will display the Main Menu screen as shown in **Figure 58**. From this screen each of the submenus may be accessed, provided the user has security access where needed, refer to **Figure 57**.

Each screen in the menu tree will show numbers in front of the subject if more information is available at the next menu level. Pressing the number for the subject using the numeric keypad will bring up that screen. If the subject is preceded by a double arrow symbol (>>) instead of a number no further information is available or the parameter may not be modified without security access.

At each screen and level in the menu tree, when finished accessing data or changing system parameters, the user may select DONE using the function keys to move back to the prior screen in the menu or when available press HOME, F5, to return to the Main Screen. On some screens such as in the History screens you will be able to access additional screens of data recorded by pressing NEXT, see **Figures 70** and **71**.

Figure 58 User level main menu screen



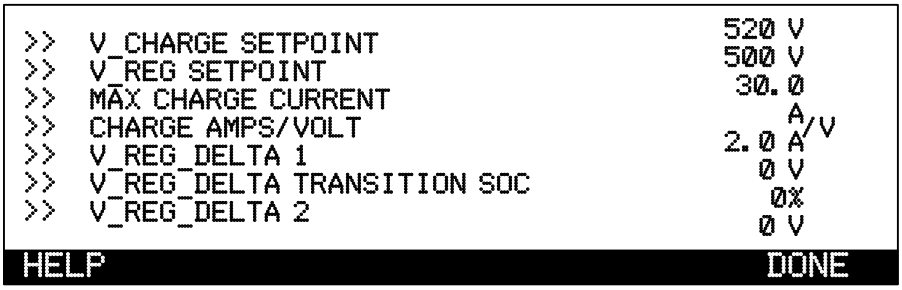
6.4.3 System Setup and Parameter Access

Setting up the Liebert FS:

In order to operate the system the system parameters must be configured for the application. The system parameters or "EEPROM" parameters can be accessed by first pressing MENU, F6, and the number one (1) button on the Control Panel keypad for the PARAMETERS screen. Liebert FS software has two kinds of access screen according to the security level.

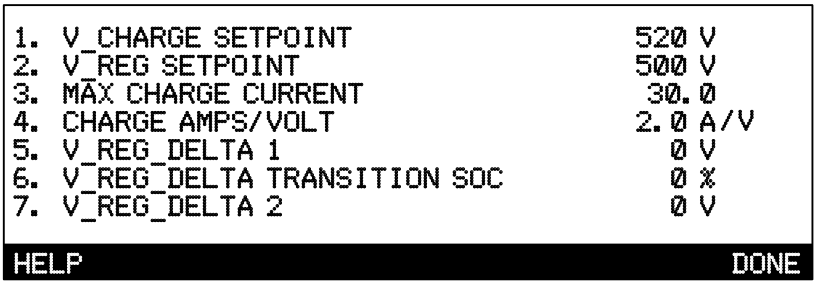
In READ-ONLY mode, seven basic parameters can be monitored. Modifying the parameters in this mode is not allowed. In this mode the parameters will have double arrow symbols to the left of the parameters.

Figure 59 READ ONLY level parameter view screen



In the USER mode, below the 7 basic parameters can be modified, see **6.3.2 - Password** for access level and passwords. Pressing the corresponding number to the parameter to the left of the number will take you to the parameter setup screen for that particular parameter.

Figure 60 USER level or above parameter edit screen



In setting the parameters there is a help screen to guide the user through the setup and help visualize the operation the system when utilizing this parameter. The help screens are displayed in **Figures 61** and **62**. The help screen also describes the other system parameters used in operation.

Figure 61 HELP screen for User Setup Parameters

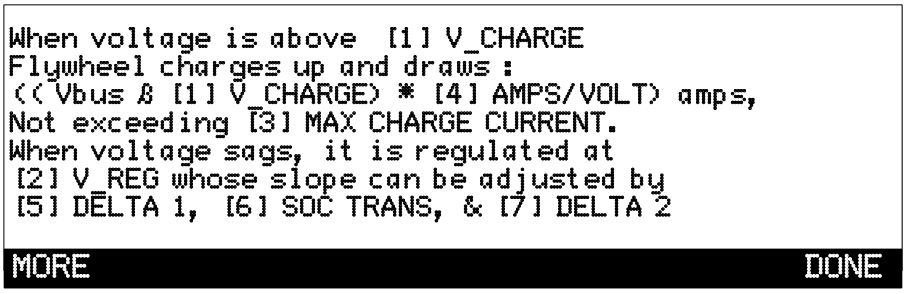
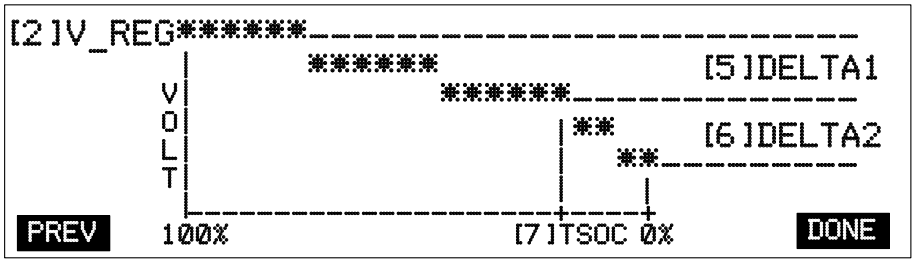


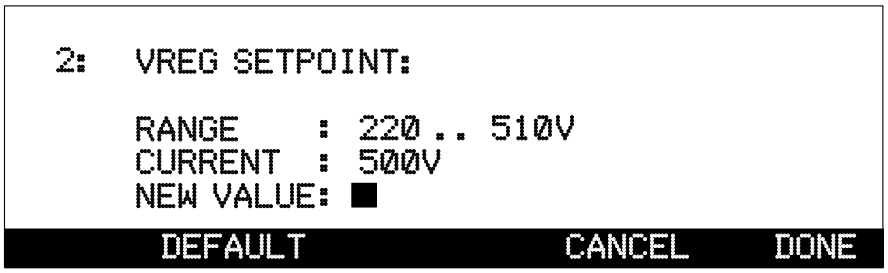
Figure 62 Graphical HELP screen for VREG DELTA1, VREG TSOC, and VREG DELTA2 Transition setup

(Pressing the "MORE" button, F1, from Figure 5-8. accesses this screen)



Each EEPROM parameter has its own screen which contains parameter description, data range, current value and default value button. Default button shows the default value for the parameter. From this screen the UP/DOWN arrow keys can used to move between parameters. The UP/Down arrow will increase/decrease the parameter number, respectively.

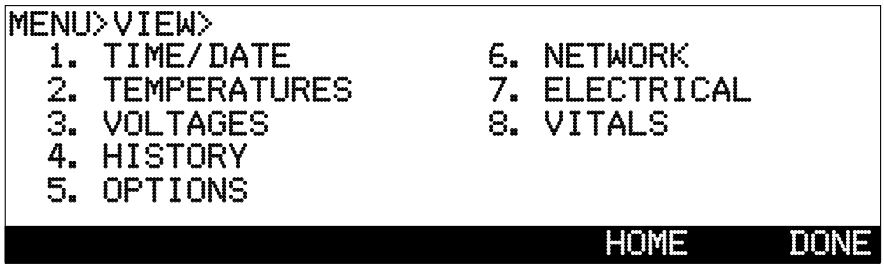
Figure 63 USER or higher level parameter selection for view/edit



6.4.4 View

Functions in MENU > VIEW display various system status including real-time and statistical data. The menu path is represented in the upper left hand corner of the screen and lets you know your current screen location in the menu tree. You can select the function by entering the number.

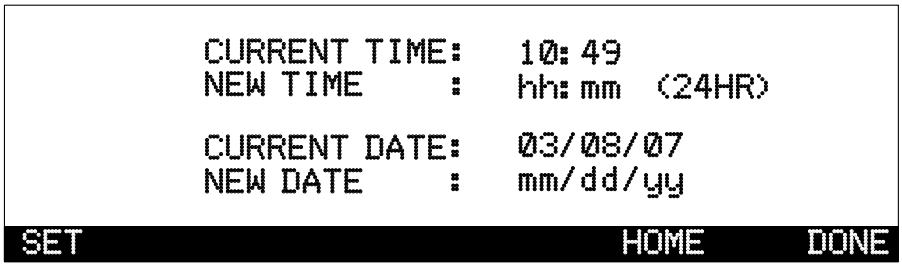
Figure 64 VIEW menu



6.4.5 Time/Date

In MENU>VIEW>TIME/DATE, system time is displayed and can be adjusted. However, USER security level or higher is required to adjust the time or date, see **6.3.2 - Password**. Pressing SET button changes to the edit mode. Cursor will blink on NEW TIME. You can type in new time data or move to NEW DATE by UP/DOWN arrow button. Moving to NEW DATE should be made before typing in any digits. All digits for time (4 digits) or date (6 digits) should be typed in before ENTER or you will get the INVALID INPUT error message.

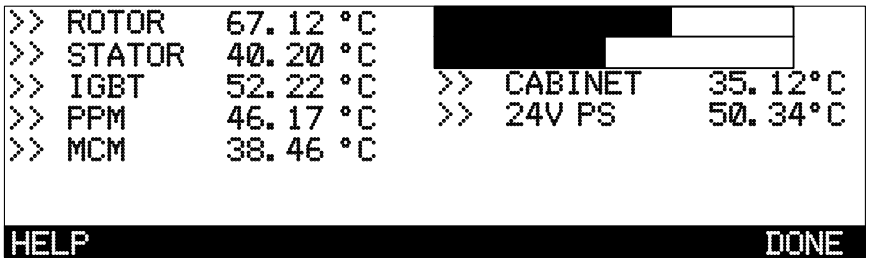
Figure 65 TIME/DATE set



6.4.6 Temperatures

MENU>VIEW>TEMPERATURES shows the temperatures of various system parts.

Figure 66 Temperature view



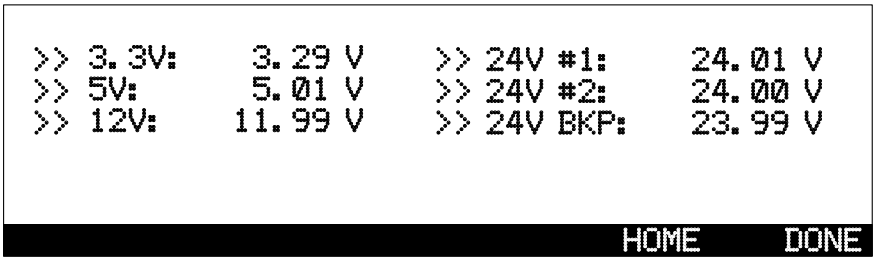
6.4.7 Voltages

MENU>VIEW>VOLTAGES shows the major power supply voltages on the controller board. These values are updated continuously.

NOTE

If an earlier model Liebert FS, serial number P or N, flywheel system has been upgraded with this software, it will display only the 24V power supply voltage.

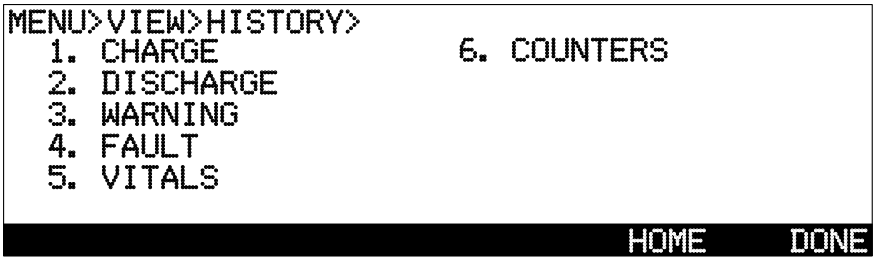
Figure 67 Figure 5-14. Voltages view



6.4.8 History

The Liebert FS records and stores a limited history of the following items; CHARGE, DISCHARGE, WARNING, FAULT, VITALS, and COUNTERS which are listed in the main History menu screen. (See **Figure 69**). In the event list screens, **Figures 71** through **73**, users may move between pages using the PREV and NEXT buttons. History data can be cleared by RESET button. SERVICE or higher level is required to reset the list.

Figure 68 History view

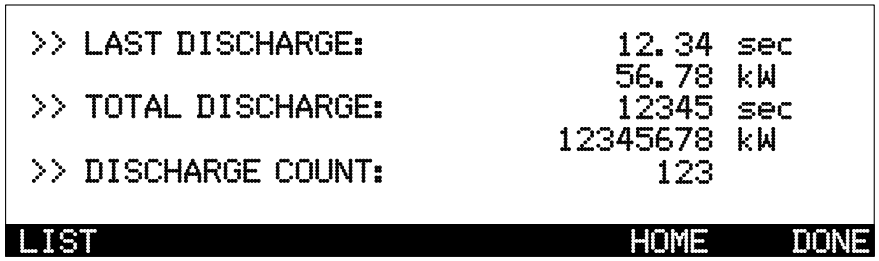


- Charge: The most recent charge (LAST CHARGE) is displayed in time (sec.) and energy (kW) on this screen as are the accumulated charge time/energy (TOTAL CHARGE). (See **Figure 69**.)

Figure 69 Charge history

- Discharge: The most recent discharge (LAST DISCHARGE) is displayed in time (sec.) and energy (kW) on this screen as are the accumulated discharge time/energy (TOTAL DISCHARGE) and the number of times system has discharged (DISCHARGE COUNT). (See**Figure 70**.)

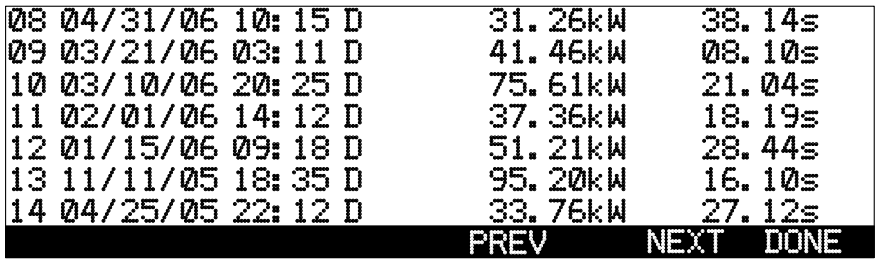
Figure 70 Discharge history



- A Discharge History event list screen, **Figure 72**, is available and shows the event number, date (month./day/year), time of event (00:00-24:00) average power (kW), and duration of discharge (seconds). The recorded events are sequentially numbered and listed from most recent to last. The letter "D" after the time indicates that this is the DISCHARGE History screen.

The first screen has the function options of NEXT or DONE viewing. The next page will have the function button options of PREV (Previous), NEXT or DONE.

Figure 71 Discharge History, Event list screen



- Warning/Fault: Liebert FS software holds 35 warning and fault event information, respectively. Seven warnings/faults are displayed in a single screen.

Figure 72 Warning history, Event list screen

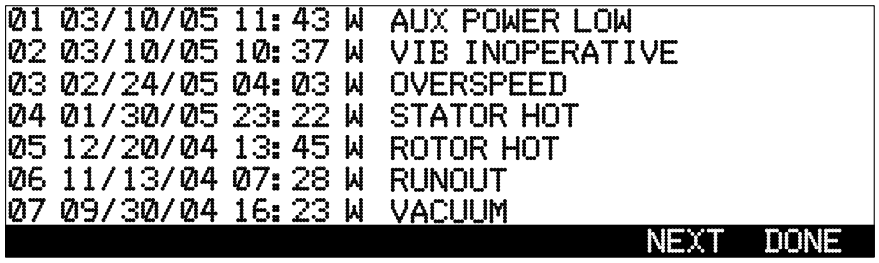
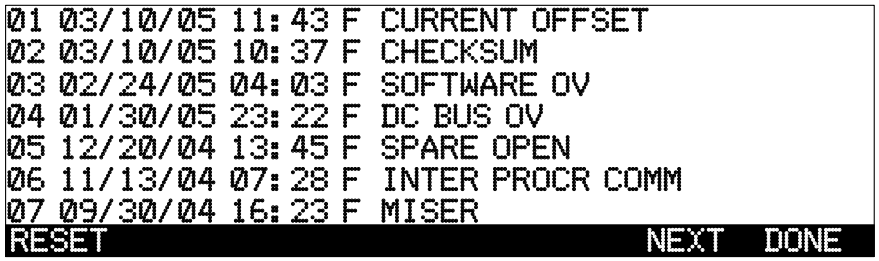
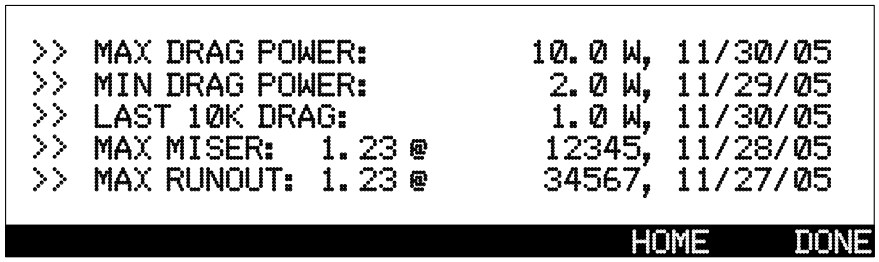


Figure 73 Fault history, Event list screen



- Vitals (USER or above): Key system efficiency and performance measurements are displayed in Max/Min measurements along with the date recorded.

Figure 74 Vitals history view



- Counters (USER or above) provide totals of run time hours; system and components, and numbers of startup and shutdown events; contactor closures and bootup. OPERATING HOURS is the total operating hours in the CHARGE/ DISCHARGE/ READY mode.

Figure 75 Counters

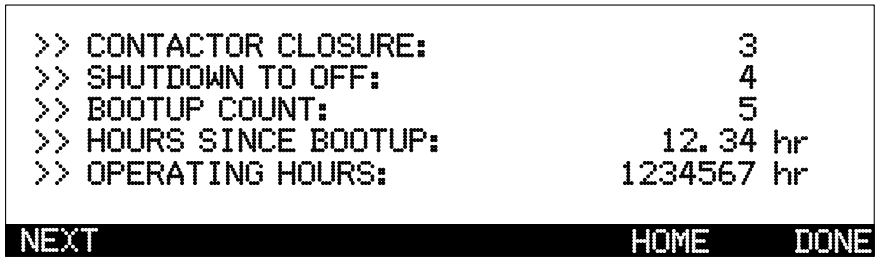
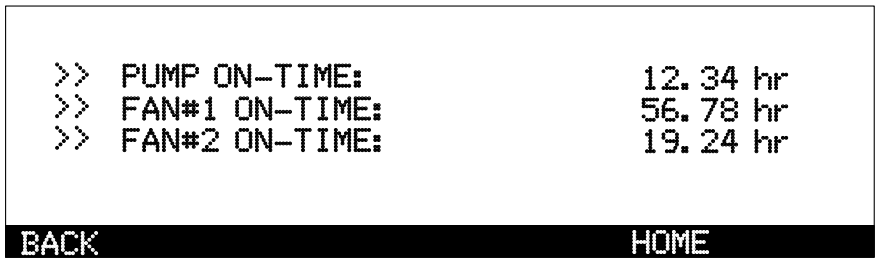


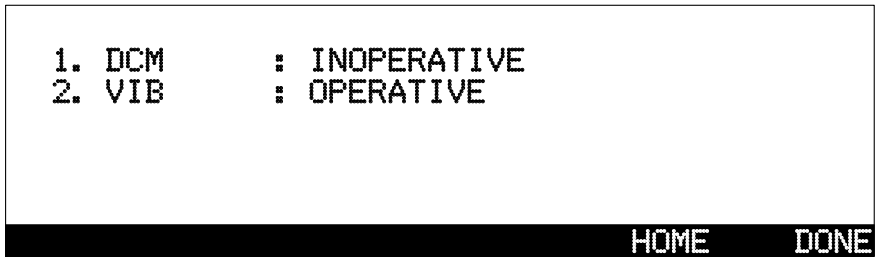
Figure 76 Counters - screen 2



6.4.9 Options

Each option, if installed, can be enabled by pressing its number and its status will then be displayed. Additional information on setup and operation of these options is available in the related section of this manual.

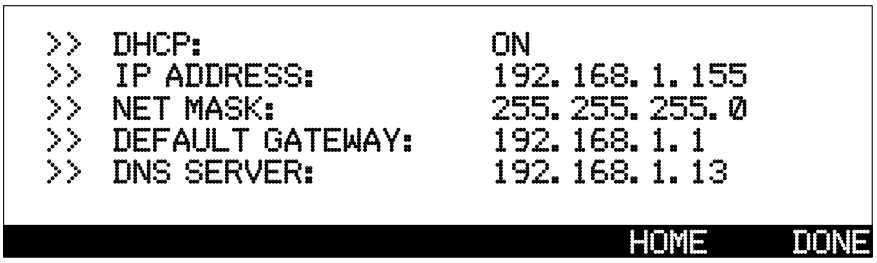
Figure 77 Options view



6.4.10 Network—Requires DCM Option

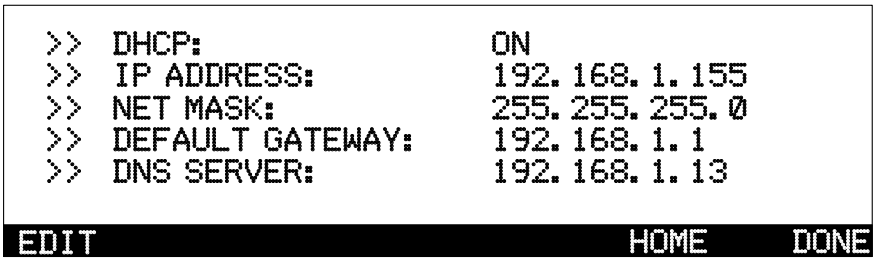
The Network view screen displays the addresses of the DCM. Static address settings can be entered using the keypad into this screen. If this option is installed, reference the Liebert Data Collection Module (DCM) Option Manual for more information on setting up the DCM on a network and or assigning IP addresses. **Figure 78** shows the Network screen in a read-only mode.

Figure 78 Networks view



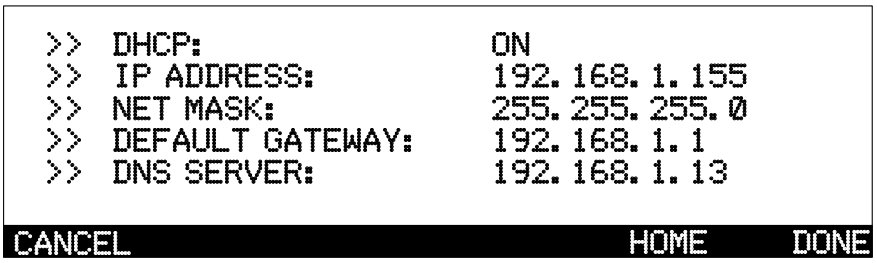
By entering a Password to access the User level mode (see **6.3.2 - Password**), you can edit this function. Pressing the EDIT button, F1, will place the system in the edit mode. The DHCP must be disabled or turned OFF to proceed with setting IP addresses and other settings. After pressing EDIT you will see up/down arrows next to the DHCP ON value. Pressing the up or down arrows on the keypad will allow you to turn OFF or ON this function.

Figure 79 Networks view, Edit DHCP



Once you have turned DHCP OFF, press EDIT again and now you will see numbers next to each of the settings. Pressing the corresponding number will allow you to enter or change that value. At any time you may press CANCEL to cancel the changes. Once the changes or entries are complete, press APPLY to complete entry process. Pressing APPLY will reboot system and in a few minutes the system will display the new screen.

Figure 80 Networks view, Edit Settings (Service level)

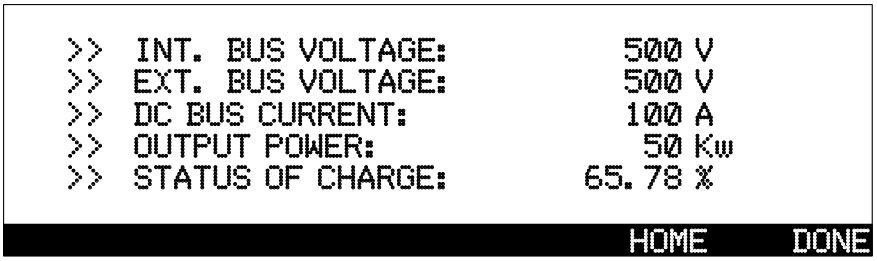


6.4.11 Electrical

The screen MENU>VIEW>ELECTRICAL shows the major electrical system variables. These quantities are updated continuously.

NOTE
Positive values for DC BUS CURRENT and OUTPUT POWER indicate Discharge mode and negative values for same indicate Charge mode.

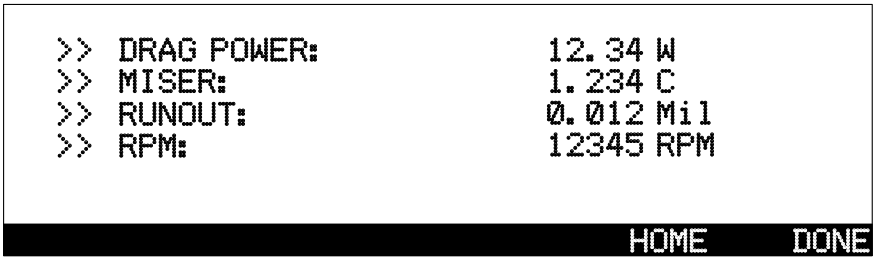
Figure 81 Electrical view



6.4.12 Vitals

MENU>VIEW>VITALS shows the current vital system values. These quantities are updated continuously.

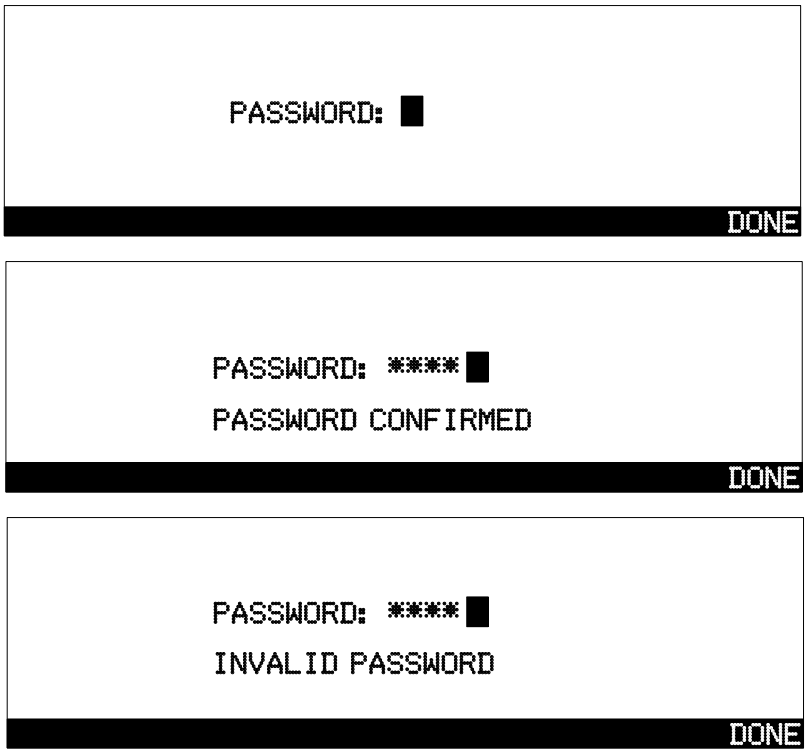
Figure 82 Vitals view



6.4.13 Security

Security levels can be changed in the MENU>SECURITY screen.

Figure 83 Password screens



USER level password can be modified by pressing the CHG PW button. Current password is required to change the password. The USER level password should be between 3 - 12 digits length, hence digits after 13th are ignored if more than 12 digits are entered.

Figure 84 Change password

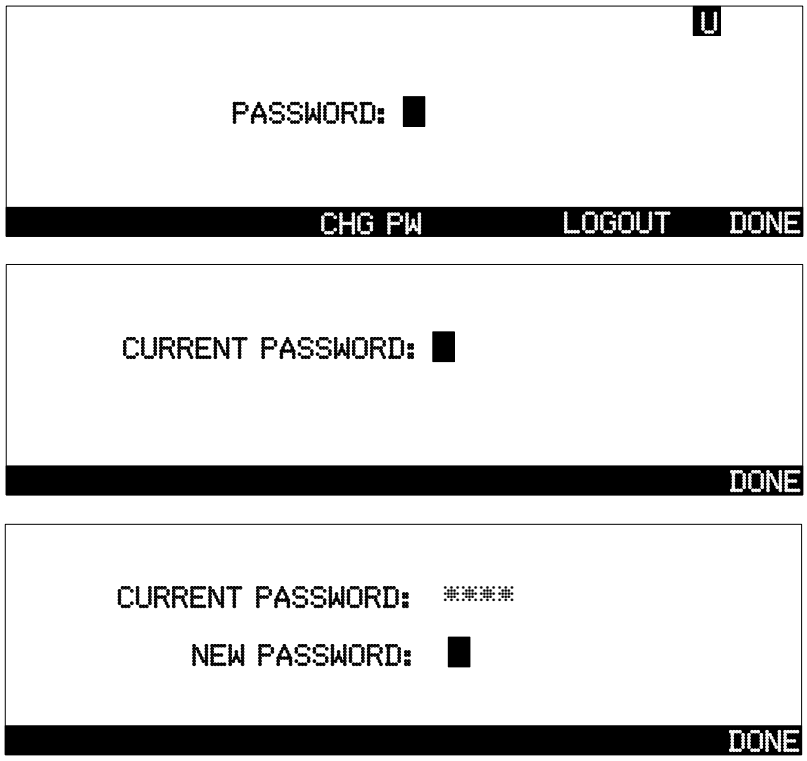
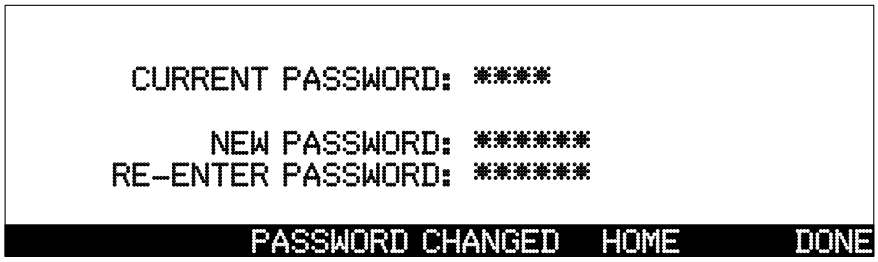


Figure 85 Change password



6.4.14 About

About screen shows the version of the firmware and company information. The controller board has two DSPs and each DSP has bootloader and application firmware.

Figure 86 ABOUT screen

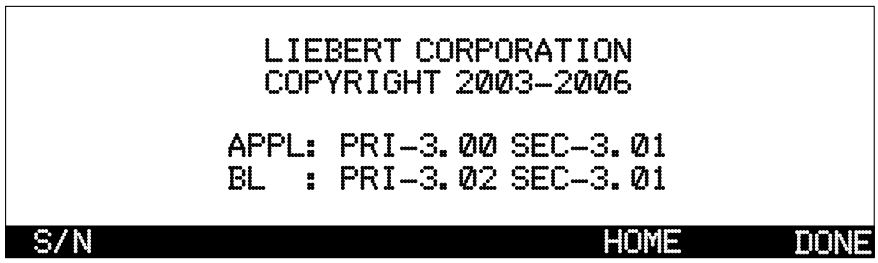
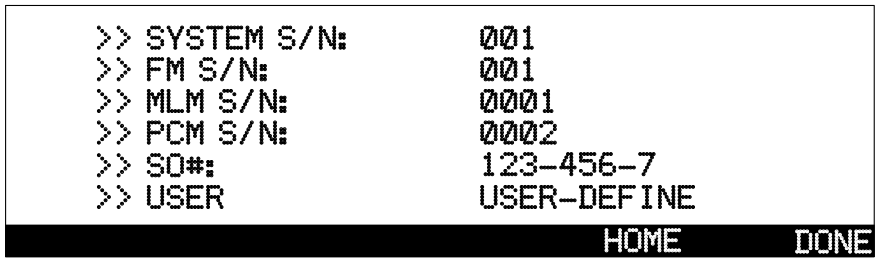


Figure 87 Serial numbers



6.4.15 Tools

Tools menu has REBOOT function for USER to reboot system.

Figure 88 Tools for USER

6.5 System Startup

6.5.1 Initial System Startup Procedure

Initial System Startup is defined as the first or initial startup following installation of the system. Several additional steps are required prior to the normal startup procedure including the following Inspection before Initial System Startup, (Section 5.5.2), and Control Parameters Setup (Section 5.5.3.). These steps are required to ensure safe and proper startup of flywheel system and for warranty purposes.

CAUTION

The Initial System Startup shall ONLY be performed under the supervision of a Liebert-certified service technician in order to ensure proper system operation. Failure to abide by instructions provided herein may void your warranty.

6.5.2 Inspection before Initial System Startup

A Liebert technician will perform the following tasks:

- **Visual Inspection**
  Inspect equipment for signs of damage
  Verify installation per drawings
  Inspect cabinet for foreign objects
  Verify ground conductors are properly sized and connected
  Verify all printed circuit boards are configured properly
- **Mechanical Inspection**
  Check all control wiring connections for tightness
  Check all power wiring connections for tightness
  Check that cabinet is attached to the floor
  Check all terminal screws, nuts and/or spade lugs for tightness
  Check all cooling pump connections
- **Electrical Inspection**
  Check fuses for continuity
  Check and verify UPS DC bus voltage
- **Pre-Startup**
  Perform MLM Pre-Start procedure using Boot Up process with UPS DC bus
  Perform MLM Inspection and test
  Verify UPS settings and adjustments
  Run pumps and fans for several minutes

6.5.3 Control Parameters Setup at Initial System Startup

Please have the relevant UPS Interconnection Kit Handbook (Liebert UPS Interconnection Kit [IKIT] Handbook for specific Brand and Model UPS) available for the Liebert technician. The Control Parameters Setup values that need to be programmed are included in this manual.

You may record in **Table 9** the values found in the specific IKIT (Interconnection Kit) Handbook for your UPS. For future reference you may also want to record Software Versions; Primary and Secondary and Bootloader Version from the About parameter screen, Section 5.4.12. above.

Table 9 Control parameters

Control Parameter	Value	Default
Charge Voltage	VDC	530
Regulation Voltage	VDC	520
Maximum Charge Current	A	30
Charging Amps/Volts	A/V	2
Vreg Delta 1	VDC	0
Vreg TSOC	%	0
Vreg Delta 2	VDC	0

Table 10 Software versions

Software Application	Version
Primary application 2812	
Secondary application 6711	
Primary Bootloader	
Secondary Bootloader	

The Liebert technician will perform or direct the Control Parameters Setup (described in **6.4.1 - Screen Tree Menu Functions**) and proceed to the Initial Startup Procedure.

NOTE

DC bus ripple voltage should be measured and taken into consideration when programming the Charge Voltage; the Charge voltage should be below the DC float voltage and include compensation for any ripple voltage present to avoid frequent charging and discharging.

6.5.4 Initial System Startup Procedure

A Liebert technician will perform or direct the following tasks at Initial System Startup:

- Inspection before Initial System Startup (Section 5.5.2. of this manual)
- System Control Parameters Setup
- Assist with Initial System Startup
- Complete Warranty documentation
- Complete commissioning documentation
- Provide basic user training on Liebert FS operation *

6.5.5 Regular Startup Procedure

CAUTION

The Initial System Startup shall be performed ONLY under the supervision of a Liebert technician to ensure proper system operation. Failure to abide by instructions provided herein may void your warranty.

NOTE

A regular startup is any startup after the Initial System Startup.

6.5.6 Inspection Before Regular Startup

The following verifications must be done before performing a regular startup of the Liebert FS (see **6.5.7 - Starting up the System**):

1. Make sure the Liebert FS is properly secured to the floor with the Liebert-provided mounting kit and in compliance with the floor mounting instructions in **4.1 - Cabinet Floor Mounting**.
2. Check for coolant leaks in and around the Liebert FS unit.
3. Ensure that Liebert FS cabinet panels are in place on the cabinet and that no tools have been left in the cabinet
4. Ensure that the Liebert FS Main circuit-breaker (optional) or the customer-provided external DC disconnect switch is open
5. Verify that the AC Auxiliary Backup Power is connected and powered by closing fused disconnect or wall disconnect and check if the Control Panel is ON and with no warning or fault messages displayed.

The Liebert FS may now be started up.

6.5.7 Starting up the System

CAUTION

The following procedure assumes that the Initial System Startup has been performed under the supervision of a Liebert technician.

Powering Up the Liebert FS

Once AC voltage is applied to the Liebert FS, the Liebert FS Control Panel will boot up. Its screen will begin to illuminate after 5 to 10 seconds and then display a series of boot up protocols.

Booting Up

1. It takes about 25 seconds to load and initialize the primary application software at STARTUP or after reset.
2. Title block and firmware versions will be displayed (see **Figure 82**). If the secondary DSP does not boot up properly, versions for the secondary DSP may be corrupted or zero.
3. EEPROM checksum will be calculated and compared with the stored value. EEPROM checksum fault will be generated if they do not match. For this case, default values are loaded for parameters in RAM. However, EEPROM contents are not changed.

CAUTION

Do not attempt to run the system unless the system loads valid parameters.

4. Response from secondary DSP will be checked. “INTERPROCESSOR COMM FAULT” will be generated if the communication is not set up properly. The controller will reset itself for this case.
5. Previous operation command (STARTUP or SHUTDOWN) will be retrieved to determine the current operation mode.
6. Option status is checked. Current available options are VIB and DCM.

Validation of Control Parameters Setup

1. Once the Control Panel has successfully booted up, the Control Panel will display the Main Screen (see **Figure 55**).
2. Verify the Control Parameters values are correct. (Consult **Table 9** and the relevant UPS Interconnection Kit Handbook for choosing the proper Control Parameters values).
3. Adjust the Control Parameters values if necessary (see **6.4.1 - Screen Tree Menu Functions**). for instruction on how to change the values of the Control Parameters) then press "F6 DONE".

Initiating Liebert FS Startup Sequence

NOTE
Startup procedures will vary for each UPS model.

1. Once sufficient DC voltage is applied to the UPS DC Bus, the Liebert FS will be able to transition from the OFF Mode to Startup Mode, unless system was previously Shutdown by command.

   The following action is conditional on the UPS interconnection kit that has been installed on your Liebert FS:

   - **Standard UPS Interconnection Kit (IKIT-STD)**

     The Standard UPS interconnection kit (IKIT-STD) includes a fused Power Terminal Block. It is recommended for maintenance use to have an external disconnect switch installed between the UPS and the Liebert FS.

     Close the customer-provided external disconnect switch at the time indicated by the UPS startup procedure.
   - **Optional UPS Interconnection Kit**

NOTE
Optional UPS interconnection kits include circuit-breakers then referred to as "Liebert FS Main circuit-breaker".

   Open the Liebert FS cabinet front door and close the Liebert FS main circuit-breaker at the time indicated by the UPS startup procedure. Close the cabinet door.
2. The Control Panel will then show the Main screen (see **Figure 55**). The System Mode should read "OFF". The Liebert FS will actively check for presence of sufficient voltage to allow system startup.
3. As soon as the UPS DC bus voltage is greater than Vcharge, the System Status will change from "OFF" to "STAND BY". The "F1 STARTUP" key will then be enabled.
4. Press the "F1 STARTUP" key.

Liebert FS Startup Sequence

As soon as the "F1 STARTUP" key is pressed, the Liebert FS will launch its startup sequence. This will progressively lead the Liebert FS through the different Modes of Operation (STAND BY, STARTUP, CHARGE) to eventually reach a ready state of idling (READY Mode) once it is completely charged up. The automatic transition between modes is described in **5.2 - List of System User-Configurable Parameters**.

6.6 Shutdown Procedure

There are two ways the Liebert FS may enter a Shutdown sequence: either **a)** following a Liebert FS discharge down to SOC = 0%; or **b)** following a user-initiated command.

In any Mode, except OFF Mode, the user may command the Liebert FS to transition in SHUTDOWN Mode by pressing the "F2 SHUTDOWN" key. This action is recommended for normal shutdown of the system. In this condition, the Liebert FS will not discharge to support an outage. You will be asked to confirm "Yes" or "No" to SHUTDOWN. Press "Yes" to confirm shutdown and put system in SHUTDOWN mode.

For more information concerning the SHUTDOWN Mode, please refer to **5.2 - List of System User-Configurable Parameters**.

7.0 MAINTENANCE

7.1 Safety Precautions

Observe all safety precautions in this manual, paying particular attention to **Important Safety Instructions on page 1**.

ONLY qualified service personnel should perform maintenance on the Liebert FS.

Observe all of the warnings below before performing any maintenance on the Liebert FS and associated equipment.

⚠ WARNING

Before performing preventive maintenance tasks, the Liebert FS must be de-energized and electrically isolated (both AC and DC connections to the Liebert FS must be electrically disconnected).

⚠ CAUTION

Always identify connecting wiring prior to disconnecting any wiring.

Do not substitute parts except as authorized by Liebert Corporation.

Keep Liebert FS cabinets free of foreign materials such as solder, wire cuttings, etc.

Contact Liebert Services if you are not sure of the procedures to follow or if you are not familiar with the circuitry.

⚠ WARNING

Extreme caution is required when performing maintenance.

Be constantly aware that the Liebert FS contains high DC as well as AC voltages. With input power off and the battery disconnected, high voltage at filter capacitors and power circuits should be discharged within 30 seconds. However, if a power circuit failure has occurred, you should assume that high voltage may still exist after shutdown. Check with a voltmeter before making contact.

Check for voltage with both AC and DC voltmeters prior to making contact.

When the Liebert FS is under power, both the operator and any test equipment must be isolated from direct contact with earth ground and the chassis frame by using rubber mats.

Some components within the cabinet are not connected to chassis ground.

Any contact between floating circuits and the chassis is a lethal shock hazard. Use differential oscilloscopes when measuring a floating circuit. The differential input should have at least 800 VRMS common mode input rating and a common mode rejection ratio of at least 80dB.

Exercise caution that the test instrument exterior does not make contact, either physically or electrically, with earth ground.

In case of fire involving electrical equipment, use only carbon dioxide fire extinguishers or others approved for use in fighting electrical fires.

7.2 Liebert Services

Startup, maintenance and training programs for the Liebert FS are available through your Liebert sales representative.

Professional Startup

Liebert FS Startup—Liebert's customer engineers perform a thorough, non-powered inspection of the units and will then conduct a complete electrical checkout that includes calibrating all components to published specifications. Customer operation training will be conducted during startup.

Load bank testing and full site acceptance testing are additional services that can be performed during a Liebert FS startup. One preventive maintenance service call can be added to the initial Liebert FS startup agreement.

Maintenance Agreements: The Signature Program

Liebert FS Service Agreements—Liebert Services has a variety of available maintenance agreements, depending on specific site needs. Choose the level of support appropriate for each installation. Mission-critical sites can have the standard parts-and-labor, around-the-clock coverage for their Liebert FS, with or without scheduled preventive maintenance visits. Other sites can benefit from a variety of money-saving options.

While the Liebert FS is designed to be maintenance-free, Liebert suggests at least one preventive maintenance visit per year. This preventive maintenance work would normally be done in conjunction with a service visit for another Liebert UPS product. The annual visit will require taking the Liebert FS off-line for a thorough, nonpowered inspection. These visits are in addition to the general housekeeping tasks (changing air filters, etc.) that can be performed by customer personnel.

Training

Customer training courses include the proper operation of the system, emergency procedures, preventive maintenance and some corrective maintenance.

Warranties

Contact Liebert Services if you have any questions regarding the warranty on your Liebert FS.

7.3 Routine Maintenance

You are encouraged to become thoroughly familiar with the equipment, but at no time should you go beyond the specific procedures in this manual while performing maintenance or correcting a malfunction. If you have any doubt as to what must be done, call Liebert Services at 1-800-LIEBERT for further instructions.

The Liebert FS is designed for unattended operation, but does require some common-sense maintenance:

- Keep good records—Troubleshooting is easier if you have historical background
- Keep it clean—Keep the Liebert FS free of dust and moisture
- Keep it cool—The Liebert FS will reliably meet all performance specifications and design life at temperatures up to 122°F (50°C)
- Keep connections tight—Tighten all connections at installation and at least annually thereafter (see torque requirements,**Table 12**)

7.4 Maintenance Schedule

WARNING

Any maintenance on the system should be delayed by at least 10 minutes after system is shut down to be certain all electronics have discharged. Use appropriate safety precautions to ensure unit is disconnected and de-energized.

CAUTION

Unless specified otherwise, ONLY a Liebert-certified service technician should perform all maintenance work. Failure to use a Liebert technician for maintenance actions, unless specifically noted, may void your warranty.

The Liebert FS maintenance schedule consists of actions listed in **Table 11**.

Table 11 Maintenance schedule

Item/Action	Frequency				Service Performer
	Every 1 yr	Every 2 yrs	Every 6 yrs	Every 15 yrs	
System Visual Inspection *	Check or Test	—	—	—	Liebert/Owner
System Cleaning (if necessary)	Check or Test	—	—	—	Liebert/Owner
System Testing (and adjustments, if necessary)	—	Check or Test	—	—	Liebert
PCM Capacitor Bank	—	—	Service or Replace	—	Liebert
Flywheel Module	Once after Startup	Check or Test	—	Service or Replace	Liebert
UPS Interconnection Kit (if option installed)	—	Check or Test	—	—	Liebert
Air Filter (if option installed)	Check or Test	—	—	—	Liebert/Owner

NOTE

The recommended System Visual Inspection every year should include a check and torque of cabinet DC circuit breaker box lug connections and the DC ground; see the relevant section of ***Appendix A.0 - UPS Interconnection Kits*** *for torque requirements.*

NOTE

Liebert may determine additional maintenance actions as necessary and issue service or technical bulletins to address any additions.

NOTE

The optional inlet Air Filter in the cabinet will need to be replaced when it is sufficiently dirty to significantly reduce the flow of air into the cabinet. Ambient conditions at the installation site will determine the frequency of replacement if option is installed

7.5 Record Log

Set up a maintenance log to record scheduled checks and any abnormal conditions.

The log should have space for all metered parameter indications including phase readings, alarm messages, mode of operation, air filter replacement date and observation notes.

A periodic walk-through inspection of the Liebert FS room is advised to check for visible and audible indications of problems. Log the inspection, metered parameter indications and any discrepancies.

7.6 Optional Air Filters

The optional air filters must be inspected and serviced on a regular schedule. The period between inspections will depend upon environmental conditions. Under normal conditions, the air filters will require cleaning or replacement approximately every 12 months.

CAUTION

Be certain recyclable filter elements are dry before reinstalling them in the Liebert FS.

Abnormal or dusty conditions will require more-frequent cleaning and replacement of air filters (sometimes as often as every two months). Inspect installations in new buildings more often, then extend the inspection period as experience dictates.

7.7 Torque Requirements

All electrical connections must be tight. **Table 12** provides the torque values for the connections in the Liebert FS. Use these values unless the equipment is labeled otherwise.

Table 12 Torque specifications (unless otherwise labeled)

Nut And Bolt Combinations				
	Grade 2 Standard		Electrical Connections With Belleville Washers	
Bolt Shaft Size	Lb-in	N-m	Lb-in	N-m
1/4	53	6.0	46	5.2
5/16	107	12	60	6.8
3/8	192	22	95	11
1/2	428	48	256	29

Circuit Breakers with Compression Lugs (For Power Wiring)		
Current Rating	Lb-in	N-m
250A	250	28

Circuit Breakers with Compression Lugs (For Control Wiring)		
AWG Wire Size or Range	Lb-in	N-m
#22 - #14	3.5 to 5.3	0.4 to 0.6

7.8 Detecting Trouble

It is important that the operator check the instrument readings if abnormal equipment performance is suspected. Any metered value that differs appreciably from normal could mean an impending malfunction and should be investigated.

Items to check include:

- Alarm messages indicate malfunction or impending malfunction. A daily check of the operator control panel will help to provide an early detection of problems. Refer to **Table 16** to interpret alarm messages.
- Tracing a problem to a particular section is facilitated by alarm messages and the metered parameter indications. These are stored in the Status Reports and can be displayed at the operator control panel or at an optional terminal. A Liebert Services engineer will be familiar with test points inside the unit.

7.9 Reporting a Problem

If a problem occurs within the Liebert FS, review all alarm messages along with other pertinent data. This information should be given by telephone to the Liebert service representative's office nearest you. This information can be downloaded to Liebert Services by using the optional modem. Contact Liebert Services at 1-800-LIEBERT to report a problem or to request assistance.

7.10 Corrective Actions

For each alarm message on the operator control panel, you can find the recommended corrective action in **Table 16**.

7.11 Recommended Test Equipment

Table 13 lists recommended test equipment and tools required to maintain, troubleshoot and repair the Liebert FS. You may substitute instruments of equivalent range and accuracy.

All instruments should be calibrated and be within the current calibration cycle. Calibration data for the instruments should be maintained in equipment-history files and the instruments labeled for audit and verification.

Table 13 Recommended test equipment and tools

Qty	Test Equipment	Manufacturer	Model or Type
1	Oscilloscope	Tektronix, H-P or Fluke	DC to 50 MHz
2	Voltage Probes	Tektronix, H-P or Fluke	10X, with 10 ft cable
2	Voltage Probes	Tektronix, H-P or Fluke	100X, with 10 ft cable
1	Digital Multi-meter	Fluke	87, with test leads
1	Tool Kit	N/A	Standard electrical contractor tools

7.12 Limited Life Components

Your Liebert FS has a design life well in excess of 15 years. Well-maintained units can continue to provide economic benefits for 20 years or more. Long-life components are used in your Liebert FS wherever practical and cost-effective.

However, due to current component material and manufacturing technology limitations, a few components in your Liebert FS will wear out and require replacement in less than 10 years. The following limited-life components are utilized in your Liebert FS. In order to prevent a wear-out failure of one of these components affecting your critical load operations, it is recommended these components be periodically inspected and replaced before their expected wear-out life. Individual users may have site-specific requirements that differ from these typical life expectations.

Table 14 Projected component life, replacement schedule

Component	Expected Life	Replace in:
Power DC filter capacitors	About 7 years	5-6 years
Air filters, disposable (see also 7.6 - Optional Air Filters)	1-3 years	Check 4 times/year

Power capacitors are considered "failed" when their measured capacitance is –5% below their nameplate rating.

In most cases, replacement components must exactly match the original component specifications and are not readily available from third-party component distributors. For assistance with your specific component specifications, replacement component selection and sourcing, call 1-800-Liebert.

For customers using Liebert Services' Preventive Maintenance Services, periodic inspection of these components are part of this service as is recommending to customers replacement intervals to avoid interruptions in critical load operations.

8.0 TROUBLESHOOTING

NOTE
Refer to this section before calling Liebert Services for support.

8.1 General

The Liebert FS is capable of detecting conditions outside of normal operating parameters and providing notice at the Control Panel. This data is recorded as either Warnings or Faults and can be viewed in the software menu tree at the screen location MENU>VIEW>. These Warnings and Faults can also be communicated by the Versatile Interface Board (VIB), if this option has been installed, to an external device or system; (see **Appendix C.0 - Versatile Interface Board**). This data will also be recorded in the Data Collection Module option if this has been selected. Please see **Appendix B.0 - Data Collection Module** for instructions on how to access this data via the DCM.

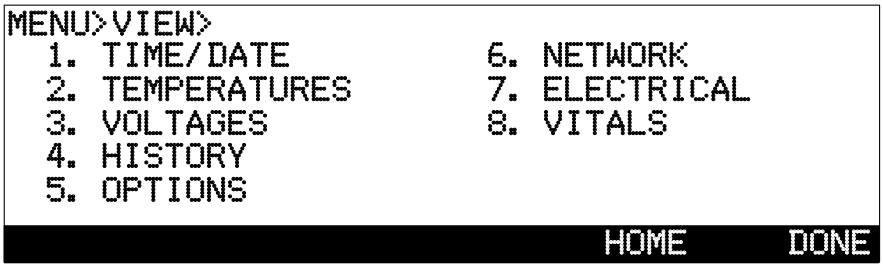
Any Warnings and Faults that may occur will be displayed on the Main screen of the Control Panel. The Liebert FS' Warnings and Faults tables (see **Tables 15** and **16**), describe these Warnings, meanings and possible causes. The operator action required or automatic system function that will result is explained.

In addition to the information displayed on the Main screen, other system information that can be used for troubleshooting is available and can be accessed from the Control Panel. From the Main screen the Menu screen can be selected by pressing (F6) on the Control Panel located below MENU.

Figure 89 USER level menu

Selecting View displays various system statuses including real-time and historical data. You can select the function by number.

Figure 90 VIEW menu



Selecting History will provide a history of Warnings and Faults as introduced in Section 5, Operations, of this manual. Other information that can be useful in troubleshooting are the Temperatures, Voltages, Options, Electrical and Vitals screens.

Warning/Fault: The Liebert FS holds 35 warning and fault information, respectively. A single screen shows seven warnings or faults. Users can move between pages using PREV, NEXT button. (See **Figures 91** and **92** below).

Figure 91 Warning history

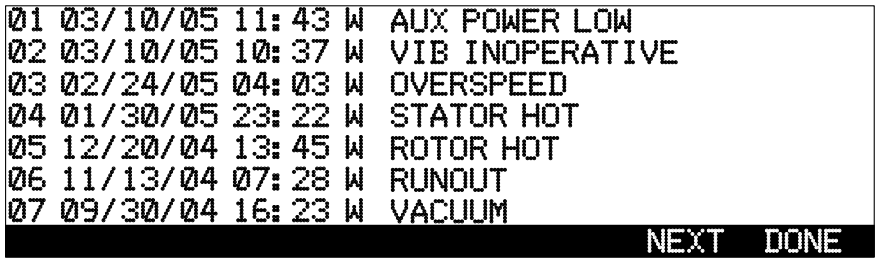
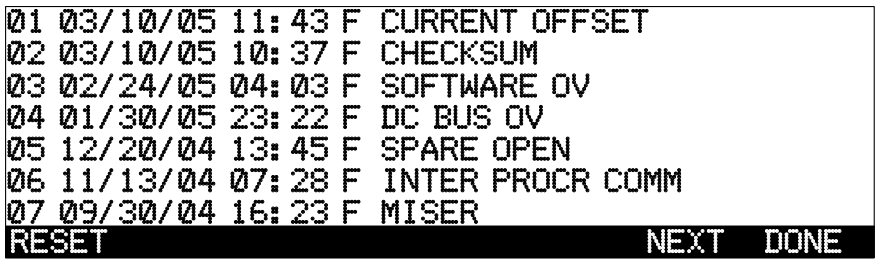


Figure 92 Fault history

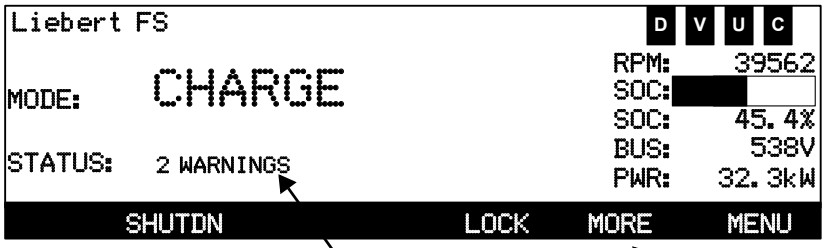


The warnings, fault meanings and possible causes in the following text and in **Table 15** may be used in troubleshooting the messages and may also aid in identifying conditions outside the flywheel system that may adversely affect it.

8.2 Warnings

A Warning is an indication of an abnormal system condition significant enough to warrant being annunciated and logged. Warning conditions may indicate that a system parameter is out of its normal operating range, or may signal an external problem. A Warning indication is for information only and does not require any operator intervention for continued operation of the unit. While in Warning condition, normal operation of the unit will continue unimpeded. A warning can indicate an operating condition that warrants observation and may require preventative maintenance.

Figure 93 Warning screen



The Warning condition is indicated by the System Status field displaying "WARNING" in the Control Panel window (see **Figure 93**). If one Warning is present, the Warning Label (see **Table 15**.) will be displayed.

While the Warning condition exists, and if more than one Warning is present, F5 the "More Info" key will be enabled in the Control Panel window. If pressed, the separate Warning Labels will be displayed in the Control Panel window.

Any of eight warnings could occur while the Liebert FS is operating. Warnings give advance alert of potential problems and schedule service and preventive maintenance. These can be monitored and investigated through the use of data from the Control Panel and system tests.

Table 15 lists the warnings and some troubleshooting steps that may be taken if any of the Warnings in appear.

Table 15 Warnings

Warning Label	Meaning / Possible Causes	Troubleshooting
AUXPOWER LOW	Auxiliary power supply is low when the system is not in OFF mode. Factory-configurable warning	Check / Test Auxiliary power supply
VACUUM LOW	Drag power exceeds 85W *	Check Vitals and Vacuum History
MISER HIGH	Miser voltage is higher than 2V	Calibrate board
RUNOUT HIGH	Runout is higher than 2.0 mil.*	Check Vitals and Runout History
PWR SPLY VOLT LOW	Power supply for PPMC/PCMC is lower than 21V.	Power supply for PPMC/PCMC is lower than 21V
VIB INOPERATIVE	VIB inoperative while enabled	Check VIB cable connections and wiring
OVERSPEED	Speed is higher than the Max Speed	Have Certified Service personnel check software settings
SET TIME/ DATE	Time and date have not been set	Set Time/Date in Menu>View>Time/Date

* Warnings of this nature should be monitored and may be used to schedule preventive maintenance.

If Warnings persist, contact your local Liebert representative or contact Liebert Services at 800-543-2378. You may also visit the Liebert Web site for information at **www.liebert.com**.

NOTE

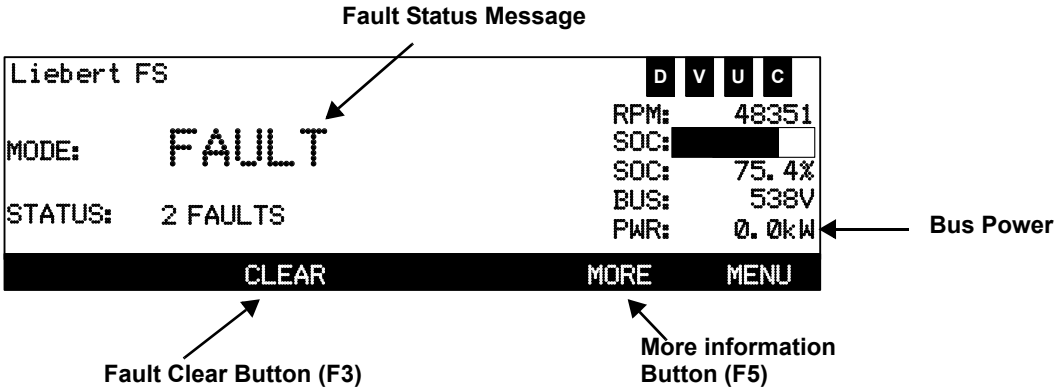
A "Standby, Motor Hot" message may be displayed as a result of consecutive and repetitive discharges. This is not a Warning but a normal operating occurrence that may occur due to frequent charging and discharging of system. Once motor cools it will automatically resume operation.

8.3 Faults

A Fault is defined as an undesirable system operating condition that could cause further damage to the system or potentially drop the load. Once detected, Faults may trigger an appropriate emergency action such as shutting the unit down. Most Fault conditions are automatically taken care of by the Liebert FS control system and require no Operator intervention. A few Fault conditions may be resolved only through operator intervention or service by a Liebert technician.

A Fault condition must be valid for a certain amount of time before it is recognized as an active Fault. This prevents spurious signals from causing false Fault detection and unnecessary state changes. **Figure 93** shows the appearance of an active Fault on the main screen.

Figure 94 Fault screen descriptions



While in Fault condition, normal operation of the unit is suspended, the operation of the Power Conversion Module is paused, and the unit transitions into FAULT Mode, where it waits for one of the following to occur:

1. The condition to clear the fault [AUTO CLEAR]
2. The unit to automatically transition in SHUTDOWN Mode [AUTO SHUTDOWN]
3. Operator action [OPERATOR CLEAR].

The Fault condition is indicated by the System Mode displaying “FAULT” in the Control Panel window.

If there are multiple Fault conditions present, the F5 “More Info” key will be enabled in the Control Panel window. If pressed, information related to the specific Faults will be displayed in the Control Panel window (see **Figures 54** through **56**). If there are multiple faults they will both be displayed by pressing the F5 “MORE” button.

In many cases, when FAULT Mode is entered, the Fault may be cleared by pressing the F3 “CLEAR FAULT” button on the Control Panel or utilizing the VIB option - if enabled - to send a “CLEAR FAULT” signal to the system. In order to “CLEAR FAULT” the operator must be in proper security access level; User or above. **Table 16** describes the fault labels, meanings and possible causes for the

Faults. **Table 17 - Troubleshooting** describes actions that may alleviate the condition or provide valuable information for technical support.

Table 16 Faults—causes and responses

Fault Label	Meaning / Possible Causes	Operator Clear*	Auto Clear	Auto Shutdown
GROUND FAULT	Ground fault current out of range.	X		
HW BUS OV	HW overvoltage. (hardware protection)	X		
X PHASE OC	AC phase overcurrent. x = A, B, C.	X		
IGBT OVRTEMP	IGBT overtemperature.	X		
VACUUM FAULT	Drag power exceeds 125W.			X
RUNOUT FAULT	Runout higher than 2.9mil.			X
MISER FAULT	Miser voltage is higher than 5V.			X
BEARING	Magnetic bearing fault.			X
AUX POWER LOW	Auxiliary power supply voltage is low when the system is in Off mode. Configurable fault.	X		
INTER PRCR COMM	Communication error with secondary DSP. System reboots.		X	
PWR SPLY VOLT	Power supply voltage is lower than 19V. (Speed dependent; auto shutdown at high speed)	X		X
UNDEF PDP INT	Undefined PDP interrupt.	X		
CURRENT OFFSET	AC motor current sensor error.	X		
SW OV	DC bus voltage is higher than the threshold, which is service-configurable.	X		
CHECKSUM	Calculated checksum does not match the stored checksum.	S		
CONTACTOR TIME OUT	Bus voltage/current is not stable while trying to close or open contactor.	X		
CONTACTOR CLOSE FAIL	Contactor failed to close on startup.	X		
FAN OPEN	Fan open circuit or disconnected.	X		
FAN SHORT	Fan short circuit.	X		
PUMP OPEN	Pump open circuit or disconnected.	X		
PUMP SHORT	Pump short circuit.	X		
HW OVERSPEED	Hardware detected overspeed.	X		
PRECHARGE PROTECTION	Stop PWM when large voltage differential exists between internal and external bus.	X		
BUS CURRENT OFFSET	DC current sensor error.	X		

S - Indicates a Certified Service Provider will be required to reset system.

NOTE

If a fault recurs after being cleared by the operator, and the condition persists, contact your Liebert technician.

Faults that initiate an AUTOSHUTDOWN include: MISER, RUNOUT, PWR SPLY VOLT (at high speed), and will require Service level and higher to reset.

Fault messages displayed can, in some cases, be investigated for a solution. Listed below in **Table 17** are troubleshooting steps for the Fault messages that can occur.

Table 17 Troubleshooting

Fault Label	Troubleshooting Action
GROUND FAULT	Contact Service provider. Schedule service.
HW BUS OV	Check DC bus voltage at UPS and adjust as necessary to within threshold.
X PHASE OC	Check IGBT, resistor diodes.
IGBT OVRTEMP	Check cooling pump, test pump and fans.
VACUUM FAULT	Check in History, Vitals, collect data, contact Certified Service Provider.
RUNOUT FAULT	Check in History, Vitals, collect data, contact Certified Service Provider.
MISER FAULT	Check calibration in Tools.
BEARING	Contact Service provider. Schedule service.
AUX POWER LOW	Check and test Auxiliary Power module.
INTER PRCR COMM	Contact Service provider. Schedule service.
PWR SPLY VOLT	Check data in Menu>View>Electrical.
UNDEF PDP INT	Contact Service provider. Schedule service.
CURRENT OFFSET	Contact Service provider. Schedule service.
SW OV	Contact Service provider. Schedule service.
CHECKSUM	Contact Service provider. Schedule service.
CONTACTOR TIME OUT	Check DC bus voltage at UPS and adjust as necessary to within threshold.
CONTACTOR CLOSE FAIL	Check DC bus voltage at UPS and adjust as necessary to within threshold.
FAN OPEN	Check fan connections.
FAN SHORT	Check fan.
PUMP OPEN	Check pump connections.
PUMP SHORT	Check pump.
HW OVERSPEED	Contact Service provider. Schedule service.
PRECHARGE PROTECTION	Contact Service provider. Schedule service.
BUS CURRENT OFFSET	Check bus voltages, contact service provider to calibrate settings.

Refer to the general drawings in **Appendix D.0 - Installation Drawings** for the location of system components.

If a Fault condition persists contact your Liebert technician. You may also visit the Liebert Web site at **www.liebert.com** for information.

APPENDIX A.0 UPS INTERCONNECTION KITS

Your Liebert FS is equipped with a UPS interconnection kit to connect it to one of these Liebert UPS systems:

- Liebert Series 610™, 600T™ or 600™
- Liebert Npower™
- Liebert Series 300™
- Liebert HiPulse™

The Liebert FS system must be installed according to the instructions in **4.0 - Installation**. Integrate your Liebert FS system into an Uninterruptible Power Supply (UPS) system in accordance with the instructions and drawings in this manual.

CAUTION

The initial system startup must be performed ONLY under the supervision of a Liebert-certified service technician to ensure proper system operation. Failure to abide by instructions provided herein may void your warranty.

Contact your local Liebert sales representative or Liebert Services at 1-800-LIEBERT to arrange for system startup.

NOTE

Before beginning installation, ensure that your Liebert FS unit is equipped with the correct UPS interconnection kit.

The first two digits of the Liebert FS model number represent the UPS system the product is designed for, as shown in ***Table 18****.*

Table 18 Key to UPS model interconnection

Liebert FS Model #	Use With Liebert UPS
25FS	Liebert Series 300
37FS	Liebert Npower
39FS	Liebert Series 610/600T/600
Contact Liebert	Liebert NXL
Contact Liebert	Liebert NX
Contact Liebert	Liebert HiPulse (50Hz European Model)

Appendix A.1 Wiring Connections

Appendix A.1.1 General Wiring Considerations

CAUTION

A qualified electrical contractor must perform all electrical connections. The wires (DC power, ground, optional status/control and auxiliary backup power) that connect the Liebert FS system(s) to the UPS system are field-supplied or, as an option, by Liebert. Wire size and installation must comply with all applicable local, regional and national regulations (e.g., National Electric Code for USA).

The electrical connections to the Liebert FS are:

- DC power
- Status/control
- Ground
- Auxiliary backup power
- Remote monitoring (optional)

NOTE

The connection instructions included in this section address ONLY the cabling of the DC power and Status/Control connections specific to the individual UPS interconnection kits.

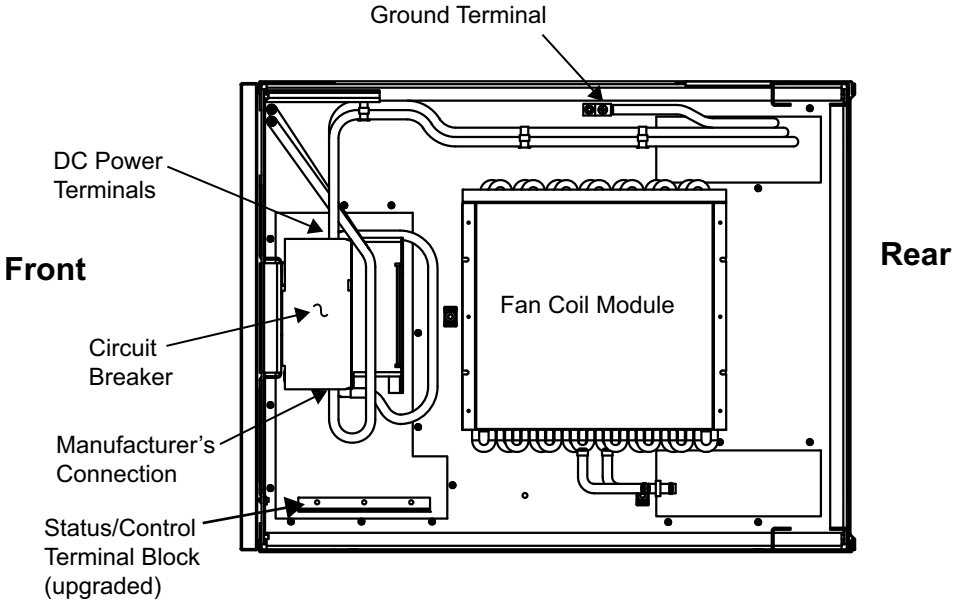
Instructions for installing ground, auxiliary backup power and remote monitoring connections are in ***4.0 - Installation****.*

Power and status/control wiring must be run in separate conduits or cable trays. Refer to **Appendix D.0 - Installation Drawings** for locations of the various electrical connections between Liebert FS system(s) and UPS system.

CAUTION

Power and status/control wiring must be separated

Figure 95 Top view of Liebert FS Cabinet with UPS interconnection kit



CAUTION

Do not cut entry holes for conduit while the access plates are still set on the top of the Liebert FS cabinet. Remove the access plates from the cable-access areas in the top of the Liebert FS cabinet prior to cutting entry holes.

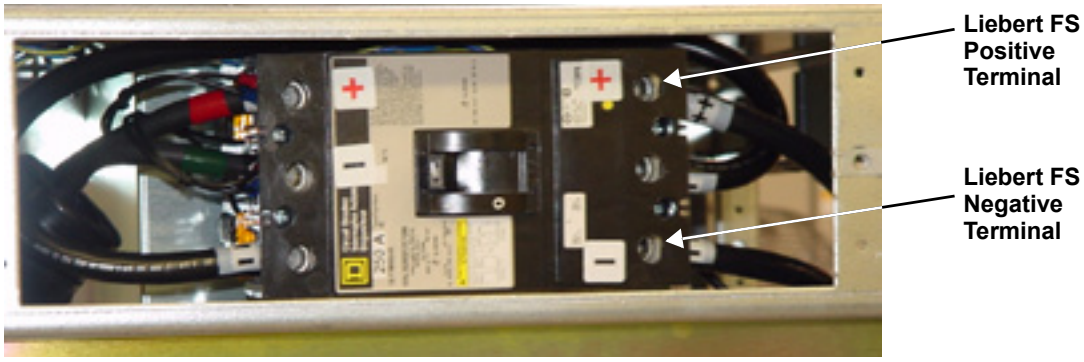
CAUTION

After reinstalling access plates, be certain that no foreign matter (metal shavings, insulation or wire fragments, etc.) remains inside the Liebert FS. Likewise, be certain to block any "extra holes" in the plates through which foreign matter (or rodents) could later enter the Liebert FS.

Appendix A.1.2 DC Power Connections

The DC power connections to the Liebert FS are made through the circuit breaker (see **Figure 96**) in the UPS interconnection kit installed in your Liebert FS. The maximum wire size for the circuit breaker terminals is 350MCM - 600VDC (approximate metric equivalent: 150mm^2 wire section). Wire size and installation must comply with all applicable local, regional and national regulations (e.g., National Electric Code for USA).

Figure 96 Circuit breaker



The Liebert FS cabinet is configured for top entry cables in standard configuration. The cables can also be run through the side panels. The Liebert FS cabinet does not accommodate bottom entry cables.

The connection of the circuit breaker is described in **Figure 135 - Elevation drawing—Liebert FS cabinet with integrated circuit breaker**. Refer to this drawing to ensure that the adequate connections are performed.

Circuit Breaker Torque

Tighten the positive and negative terminals of the DC power connections on the circuit breaker to 250 in-lb. (29 N-m) unless the equipment is labeled with a different torque value.

Appendix A.2 Installing the Liebert FS With a Liebert Series 610, Liebert Series 600T or Liebert Series 600

The Liebert Series 610/600T/600 UPS interconnection kit for the Liebert FS is compatible with the Liebert Series 610, Liebert Series 600T and Liebert Series 600 models in **Table 19**.

Table 19 Liebert Series 610/600T/600 model ratings

UPS Output Rating																
kVA	65	80	100	125	150	225	300	400	400	450	500	500	625	750	750	1,000
kW	52	64	80	100	120	180	240	320	360	360	400	450	500	600	675	900

Figure 97 Liebert Series 610 225kVA UPS

Appendix A.2.1 Description - Liebert Series 610/600T/600 UPS Interconnection Kit

The Liebert Series 610/600T/600 UPS interconnection kit for the Liebert FS is composed of:

DC Power Interface

One Thermal-Magnetic Molded Case circuit breaker rated for 250 ADC - 600VDC equipped with:

- An undervoltage relay (UVR) rated for 48VDC, 50 mA
- Auxiliary contacts: Normally Open (NO) and Normally Closed (NC).

Status/Control Interface

One Status/Control Terminal Block used to ensure the status/control connections between the Liebert FS and the Liebert Series 610/600T/600.

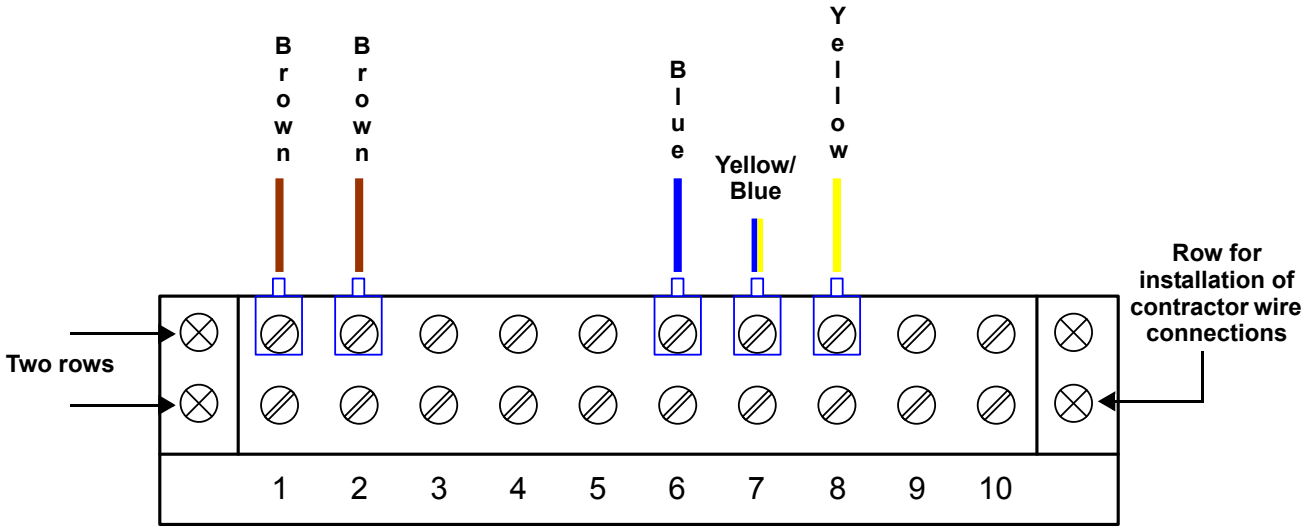
Appendix A.2.2 Status/Control Connections - Liebert Series 610/600T/600 UPS Interconnection Kit

The status/control interface is the Status/Control Terminal Block. The connection of the Status/Control Terminal Block is described in **Figure 137 - Control wiring diagram—Liebert FS cabinet - manually operated circuit breaker**. Refer to this drawing to ensure that proper connections are performed. In case multiple Liebert FS units are connected to the same UPS DC bus, refer to **Figure 129 - Control wiring—external interconnect diagram, Liebert FS cabinet to Liebert Series 610 UPS module** to perform the Status/Control connections between each Liebert FS.

This interconnection kit includes Status/Control Connections that enable transfer of signals between the Liebert FS system(s) and the UPS system such as:

- Circuit breaker status (closed/open); and
- Undervoltage relay coil excitation voltage.

Figure 98 Liebert Series 610/600T/600 status/control terminal block wiring



The recommended gauge for Status/Control connection wires is 16 AWG - 600VDC (1.3mm^2 wire section). Wire size and installation must comply with all applicable local, regional and national regulations (e.g., National Electric Code for USA).

Appendix A.2.3 UPS Configuration - Liebert FS and Liebert Series 610, 600T or 600

To optimize the integration between the Liebert Series 610/600T/600 UPS system and the Liebert FS, some parameters must be checked on the UPS system:

- The UPS rectifier walk-in time must be set as short as possible. Contact your Liebert representative if your unit has received the upgraded board that enables the setting of "rectifier walk-in time" lower than standard.
- Ensure that the "auto battery self test" has either been disabled or upgraded to accommodate Liebert FS integration.

Appendix A.2.4 Liebert FS Configuration - Single Liebert FS on Liebert Series 610/600T/600 DC Bus

The following Software Control Parameters must be set when the Liebert FS is connected to the DC bus of the Liebert Series 610/600T/600 UPS system.

NOTE
The Software Control Parameter values specified below are recommended. These values may require adjustments due to the battery type. These must be used unless otherwise specified by the Liebert-certified service technician at initial system startup.

Instructions to set these parameters on the Liebert FS are in **6.5.3 - Control Parameters Setup at Initial System Startup**.

Table 20 Liebert FS Software Control Parameter settings

Liebert FS Software Control Parameter	Setting
Charge Voltage	530VDC
Regulation Voltage	520VDC
Vreg Delta	0VDC
Maximum Charge Current	See **Table 21**
Charge Amps/Volts	See **Table 21**

Table 21 Liebert FS Software Control Parameters varying with UPS size

UPS Output Rating (kVA)	65	80	100	125	150
Liebert FS Maximum Charge Current (A)	25	31	39	49	50
Liebert FS Charge Amps/Volts (A/V)	1.7	2.1	2.6	3.3	3.4

Appendix A.2.5 Liebert FS Configuration - Multiple Liebert FS Units on Liebert Series 610/600T/600 DC Bus

The Liebert FS Software Control Parameters must be reset when multiple Liebert FS units are connected in parallel on the DC bus of a Liebert Series 610/600T/600 UPS system.

Instructions to set these parameters on the Liebert FS are in **6.5.3 - Control Parameters Setup at Initial System Startup**.

Multiple Liebert FS Parallel Operation - Regular Configuration with Liebert Series 610/600T/600

The Liebert FS Software Control Parameters must be reset when multiple Liebert FS units are connected in parallel on the DC bus of a Liebert Series 610/600T/600 UPS system for proper operation with longer run times or higher backup power requirements. The Liebert FS units will contribute all together at the same time to the task of supporting the UPS DC bus.

NOTE
This configuration is recommended for UPS models with output power levels greater than 150 kVA (i.e., 225, 300, 400, 450, 500, 625, 750 and 1,000 kVA).

NOTE
In this configuration, the UPS DC bus usually does NOT have batteries in parallel with the Liebert FS units, however, parallel operation with batteries is acceptable. If batteries to be used are in parallel with the Liebert FS units on the UPS DC bus, contact your local Liebert sales representative to arrange a review of the application.

NOTE
Your Liebert-certified service technician will configure the Software Control Parameter values at initial system startup depending on the number of paralleled units.

Appendix A.3 Installing the Liebert FS With a Liebert Npower UPS

The Liebert Npower UPS interconnection kit for the Liebert FS is compatible with the Liebert Npower models in **Table 22**.

Table 22 Liebert Npower model ratings

UPS Output Rating	kVA	30	40	50	65	80	100	130
	kW	24	32	40	52	64	80	104

Figure 99 Liebert FS integrated into a Liebert Npower UPS system

Appendix A.3.1 Description - Liebert Npower UPS Interconnection Kit

The Liebert Npower UPS interconnection kit for the Liebert FS is composed of:

DC Power Interface

One Thermal-Magnetic Molded Case circuit breaker rated for 250 ADC - 600VDC equipped with:

- An undervoltage relay (UVR) rated for 24VDC, 50 mA
- Auxiliary contacts: Normally Open (NO) and Normally Closed (NC).

Status/Control Interface

One Liebert Npower Battery Information Board (BIB). This board is used to ensure the status/control connections between the Liebert FS and the Liebert Npower.

Appendix A.3.2 Status/Control Connections - Liebert Npower UPS Interconnection Kit

The status/control interface is the Liebert Npower Battery Information Board (BIB). The connection of the BIB is described in **Figure 140 - Control wiring diagram—Liebert FS - optional electrically operated circuit breaker Liebert Npower units**. Refer to this drawing to ensure that the proper connections are performed. In case multiple Liebert FS units are connected to the same UPS DC bus, refer to **Figure 132 - Control wiring diagram, Liebert FS power rack system in parallel for capacity** to perform the Status/Control connections between each Liebert FS.

This interconnection kit includes Status/Control Connections that enable transfer of signals between the Liebert FS system(s) and the UPS system such as:

- Circuit breaker status (closed/open); and
- Undervoltage relay coil excitation voltage.

The recommended gauge for status/control connection wires is 16 AWG - 600VDC (1.3mm^2 wire section). Wire size and installation must comply with all applicable local, regional and national regulations (e.g., National Electric Code for USA).

Appendix A.3.3 UPS Configuration - Liebert FS and Liebert Npower

To optimize the integration between the Liebert Npower UPS system and the Liebert FS, some parameters must be checked on the UPS system:

- The UPS rectifier walk-in time must be set at a value as low as possible. Contact your Liebert representative if your unit has received the upgraded board that permits the setting of "rectifier walk-in time" lower than standard.
- Ensure that the "auto battery self test" has either been disabled or upgraded to accommodate Liebert FS integration.

Appendix A.3.4 Liebert FS Configuration - Single Liebert FS Unit

The following Software Control Parameters must be set when the Liebert FS is connected to the DC bus of the Liebert Npower UPS system.

NOTE

The Software Control Parameter values specified below are recommended. These values may require adjustments due to the battery type. These must be used unless otherwise specified by the Liebert-certified service technician at initial system startup. Instructions to set these parameters on the Liebert FS are in **6.5.3 - Control Parameters Setup at Initial System Startup**.

Table 23 Liebert FS Software Control Parameters

Liebert FS Software Control Parameter	Setting
Charge Voltage	530VDC
Regulation Voltage	520VDC
Vreg Delta	0VDC
Maximum Charge Current	See **Table 24**
Charge Amps/Volts	See **Table 24**

Table 24 Liebert FS Software Control Parameters varying with UPS size

UPS Output Rating (kVA)	30	40	50	65	80	100	130
Liebert FS Maximum Charge Current (A)	11	15	19	25	31	38	50
Liebert FS Charge Amps/Volts (A/V)	0.8	1.0	1.3	1.7	2.1	2.6	3.4

Appendix A.3.5 Liebert FS Configuration - Multiple Liebert FS Units on Liebert Npower DC Bus

Liebert FS Software Control Parameters must be reset when multiple Liebert FS units are connected in parallel on the DC bus of a Liebert Npower UPS system for proper operation with longer run times or higher backup power requirements.

Instructions to set these parameters on the Liebert FS are in **6.5.3 - Control Parameters Setup at Initial System Startup**.

NOTE

In this configuration, the UPS DC bus usually does NOT have batteries in parallel with the Liebert FS units, however, parallel operation with batteries is acceptable. If batteries to be used are in parallel with the Liebert FS units on the UPS DC bus, contact your local Liebert sales representative to arrange a review of the application.

NOTE

Your Liebert-certified service technician will configure the Software Control Parameter values at initial system startup depending on the number of paralleled units.

Appendix A.4 Installing the Liebert FS With a Liebert Series 300 UPS

The Liebert Series 300 UPS interconnection kit for the Liebert FS is compatible with the Liebert Series 300 models in **Table 25**.

Table 25 List of Liebert Series 300 models ratings

UPS Output Rating										
kVA	10	15	20	30	40	50	65	75	100	125
kW	8	12	16	24	32	40	52	60	80	100

Figure 100 Liebert Series 300 UPS

Appendix A.4.1 Description - Liebert Series 300 UPS Interconnection Kit

The Liebert Series 300 UPS interconnection kit for the Liebert FS is composed of:

DC Power Interface

One Thermal-Magnetic Molded Case circuit breaker rated for 250 ADC - 600VDC equipped with:

- An undervoltage relay (UVR) rated for 24VDC, 50 mA
- Auxiliary contacts: Normally Open (NO) and Normally Closed (NC).

Status/Control Interface

One status/control terminal Block used to ensure the status/control connections between the Liebert FS and the Liebert Series 300.

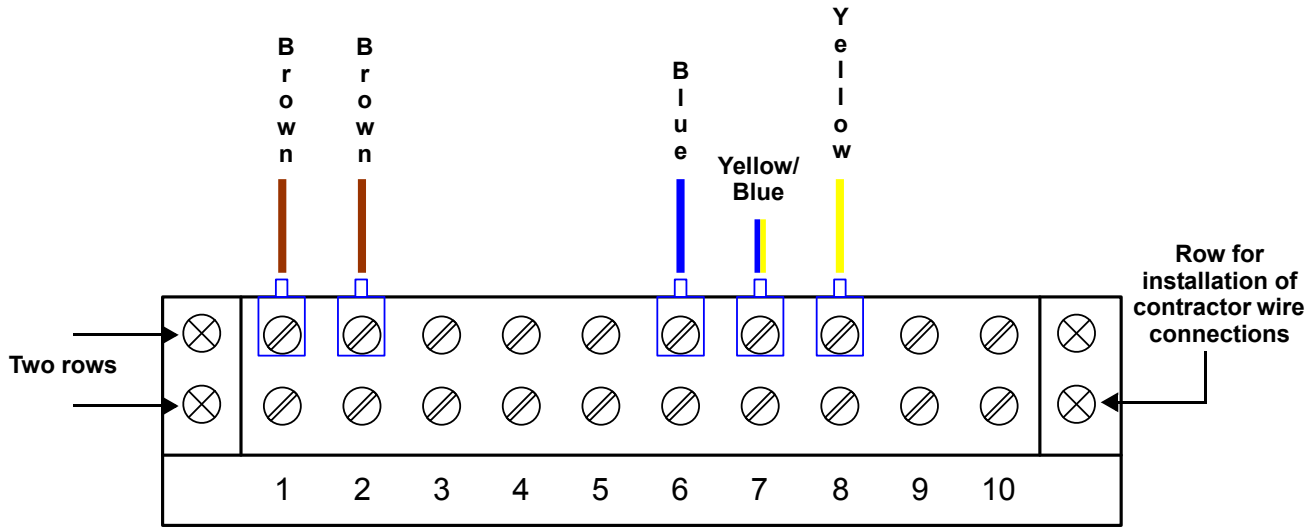
Appendix A.4.2 Status/Control Connections - Liebert Series 300 UPS Interconnection Kit

The status/control interface is the Status/Control Terminal Block. The connection of the Status/Control Terminal Block is described in the **Figure 137 - Control wiring diagram—Liebert FS cabinet - manually operated circuit breaker**. Refer to this drawing to ensure that the adequate connections will be performed. If multiple Liebert FS units are connected to the same UPS DC bus, refer to **Figure 129 - Control wiring—external interconnect diagram, Liebert FS cabinet to Liebert Series 610 UPS module** to perform the Status/Control connections between each Liebert FS.

This interconnection kit includes status/control connections that enable transfer of signals between the Liebert FS system(s) and the UPS system such as:

- Circuit breaker status (closed/open); and
- Undervoltage relay coil excitation voltage

Figure 101 Liebert Series 300 status/control terminal block wiring



The recommended gauge for status/control connection wires is 16 AWG - 600VDC (1.3mm^2 wire section). Status/Control wires must be sized and installed in compliance with all applicable local, regional and national regulations (e.g., National Electric Code for USA).

Appendix A.4.3 UPS Configuration - Liebert FS and Liebert Series 300

To optimize the integration between the Liebert Series 300 UPS system and the Liebert FS, some parameters must be checked on the UPS system:

- The UPS rectifier walk-in time must be set at a value as low as possible. Contact your Liebert representative if your unit has received the upgraded board that enables the setting of “rectifier walk-in time” lower than standard.
- Ensure that the “auto battery self test” has been either disabled or upgraded to accommodate Liebert FS integration.

Appendix A.4.4 Liebert FS Configuration - Single Liebert FS on Series 300 DC Bus

The following Software Control Parameters must be reset when the Liebert FS is connected to the DC Bus of the Liebert Series 300 UPS system.

NOTE

The Software Control Parameter values specified below are recommended. These values may require adjustments due to the battery type. These must be used unless otherwise specified by the Liebert-certified service technician at initial system startup.

Instructions to set these parameters on the Liebert FS are in **6.5.3 - Control Parameters Setup at Initial System Startup**.

Table 26 Liebert FS Software Control Parameter settings

Liebert FS Software Control Parameter	Setting
Charge Voltage	395VDC
Regulation Voltage	385VDC
Vreg Delta	0VDC
Maximum Charge Current	See **Table 27**
Charge Amps/Volts	See **Table 27**

Table 27 Liebert FS Software Control Parameters varying with UPS size

UPS Output Rating (kVA)	10	15	20	30	40	50	65	75	100	125
Liebert FS Maximum Charge Current (A)	5	8	10	16	21	26	34	39	50	50
Liebert FS Charge Amps/Volts (A/V)	0.7	1.1	1.4	2.1	2.8	3.5	4.5	5.2	6.7	6.7

Appendix A.4.5 Liebert FS Configuration - Multiple Liebert FS Units on Liebert Series 300 DC Bus

Liebert FS Software Control Parameters must be reset when multiple Liebert FS units are connected in parallel on the DC bus of a Liebert Series 300 UPS system for proper operation with longer run times or higher backup power requirements.

Instructions to set these parameters on the Liebert FS are in **6.5.3 - Control Parameters Setup at Initial System Startup**.

NOTE

In this configuration, the UPS DC bus usually does NOT have batteries in parallel with the Liebert FS units, however, parallel operation with batteries is acceptable. If batteries to be used are in parallel with the Liebert FS units on the UPS DC bus, contact your local Liebert sales representative to arrange a review of the application.

NOTE

Your Liebert-certified service technician will configure the Software Control Parameter values at initial system startup depending on the number of paralleled units.

Appendix A.5 Installing the Liebert FS With a Liebert HiPulse UPS

The Liebert HiPulse UPS interconnection kit for the Liebert FS is compatible with the Liebert HiPulse™ models in **Table 28**.

Table 28 Liebert HiPulse model ratings

UPS Output Rating									
kVA	80	120	160	200	300	400	500	600	800
kW	64	96	128	160	240	320	400	480	640

Appendix A.5.1 Description—HiPulse UPS Interconnection Kit

HiPulse UPS interconnection kit is composed of:

DC Power Interface

One Thermal-Magnetic Molded Case circuit-breaker rated for 250 ADC, 600VDC equipped with auxiliary contacts: two (2) sets of Normally Open (NO) and Normally Closed (NC).

Status/Control Interface

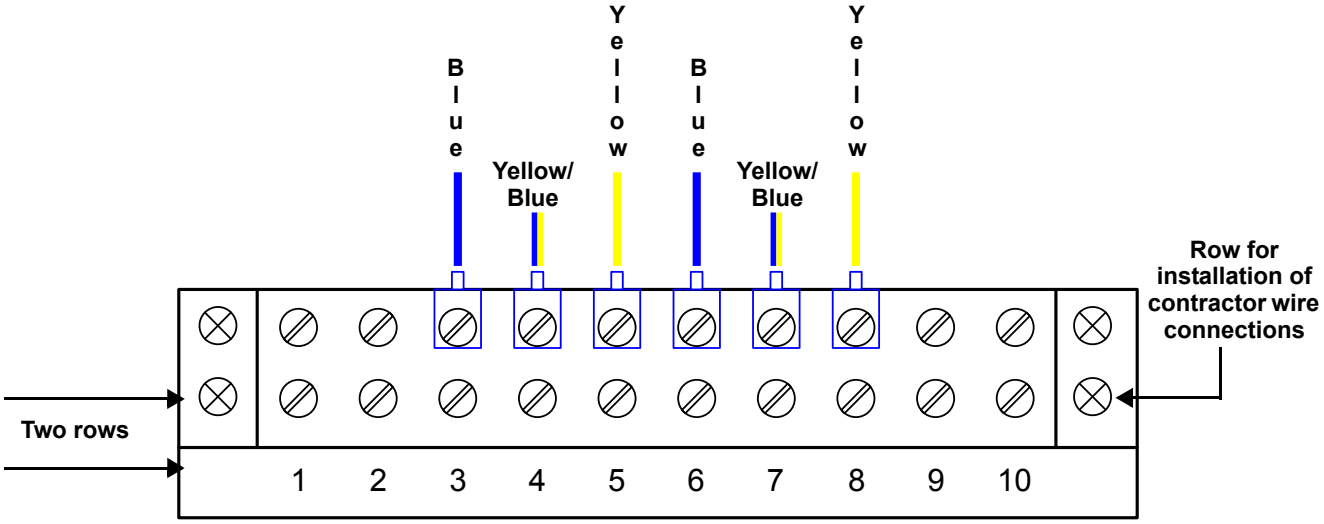
One Status/Control Terminal Block used to ensure the status/control connections between the Liebert FS and the Liebert HiPulse.

Appendix A.5.2 Status/Control Connections—Liebert HiPulse UPS Interconnection Kit

The status/control interface of the IKIT-A05 is the Status/Control Terminal Block. The connection of the Status/Control Terminal Block is illustrated in **Figure 102**. Please refer to this drawing to ensure that the proper connections are made. In case multiple Liebert FS units are connected to the same UPS DC bus, please refer to **Figure 144** to perform the Status/Control connections between each Liebert FS.

This IKIT includes Status/Control Connections that enable transfer of "IKIT circuit-breaker status (closed/open)" signals between the Liebert FS system(s) and the UPS system.

Figure 102 Liebert HiPulse status/control terminal block wiring

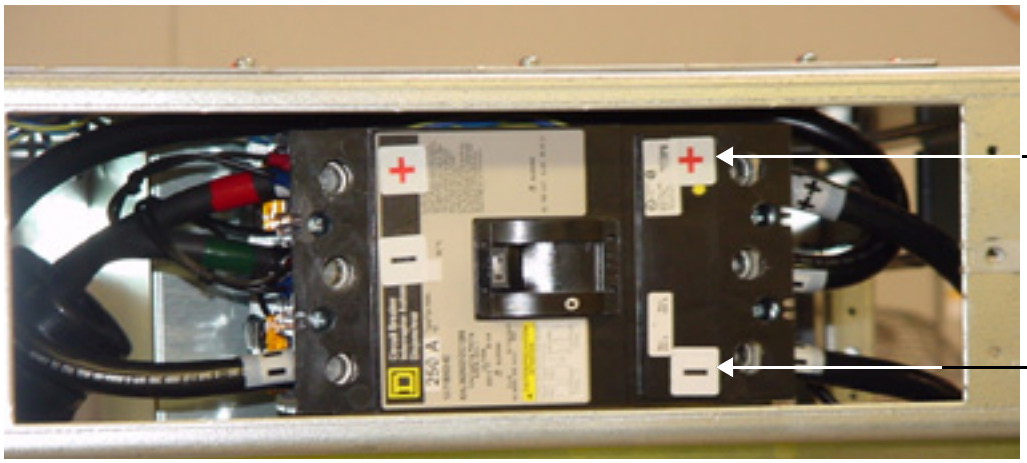


The recommended gauge for Status/Control Connection wires is 16 AWG – 600 VDC (approximate metric equivalent: 1.3 mm² wire section). All wiring must comply with all applicable local, regional, national regulations.

Appendix A.5.3 IKIT-A05 DC Power Connections

The DC power connections to the Liebert FS are made through the circuit-breaker (see **Figure 103**) in the IKIT-A05. The minimum wire size to be used is 1/0 AWG - 600VDC wire (54 mm^2 wire section). The maximum wire size for the circuit-breaker terminals is 350MCM – 600VDC (150 mm^2 wire section). All wiring must comply with all applicable local, regional, national regulations. Use copper conductors only, rated minimum 140°F (60°C).

Figure 103 Circuit-breaker (open door and cabinet faceplate removed)



The Liebert FS cabinet is configured for top entry cables in standard configuration. The cables can also be run through the side panels. The Liebert FS cabinet does not accommodate bottom entry cables.

The connection of the circuit-breaker is described in **Figure 135 - Elevation drawing—Liebert FS cabinet with integrated circuit breaker**. Refer to this drawing to ensure that the proper connections are made.

Circuit Breaker Torque

Tighten the positive and negative terminals of the DC power connections on the circuit breaker to 250 in-lb. (29 N-m) unless the equipment is labeled with a different torque value.

Appendix A.5.4 UPS Configuration—Liebert FS and Liebert HiPulse

To optimize the integration between the interconnected UPS system and the Liebert FS, some parameters must be checked on the UPS system:

- The UPS rectifier walk-in time must be set at a value as low as possible. Please check with your UPS Manufacturer representative if your unit has received the upgraded board that enables the setting of “rectifier walk-in time” lower than standard.
- Check that the “auto battery self test” has either been disabled or upgraded to accommodate Liebert FS integration.

Appendix A.5.5 Single Liebert FS on UPS DC Bus

The following Liebert FS Software Control Parameters must be set when a single Liebert FS is connected alone on the DC bus of the Liebert HiPulse UPS system.

NOTE
The Software Control Parameter values specified below must be used unless otherwise specified by the Liebert-certified service technician at Initial System Startup.

Instructions on setting these parameters on the Liebert FS are found in **6.5.3 - Control Parameters Setup at Initial System Startup**.

Table 29 Liebert FS Software Control Parameter settings

Liebert FS Software Control Parameter	Setting
Charge Voltage	436 VDC
Regulation Voltage	426 VDC
Vreg Delta	0 VDC
Maximum Charge Current	See **Table 30**
Charge Amps/Volts	See **Table 30**

Table 30 Liebert FS Software Control Parameters varying with UPS size

UPS Output Rating (kVA)	80	120
Liebert FS Maximum Charge Current (A)	39	50
Liebert FS Charge Amps/Volts (A/V)	4	5

Appendix A.5.6 Single Liebert FS in Parallel with Battery Pack on UPS DC Bus

The following Software Control Parameters must be reset when the Liebert FS is connected in parallel with a battery pack on the DC bus of the Liebert Hipulse UPS system.

NOTE
The Software Control Parameter values specified below must be used unless otherwise specified by the Liebert-certified service technician at Initial System Startup. These values may require adjustments due to the battery type.

Instructions on setting these parameters on the Liebert FS are found in **6.5.3 - Control Parameters Setup at Initial System Startup**.

Table 31 Liebert FS Software Control Parameter settings

Liebert FS Software Control Parameter	Setting
Charge Voltage	436 VDC
Regulation Voltage	426 VDC
Vreg Delta	0 VDC
Maximum Charge Current	See **Table 32**
Charge Amps/Volts	See **Table 32**

Table 32 Liebert FS Software Control Parameters varying with UPS size

UPS Output Rating (kVA)	80	120
Liebert FS Maximum Charge Current (A)	39	50
Liebert FS Charge Amps/Volts (A/V)	4	5

Appendix A.5.7 Liebert FS Configuration – Multiple Liebert FS Units

Liebert FS Software Control Parameters must be reset when multiple Liebert FS units are connected in parallel on the DC bus of a Liebert HiPulse™ UPS system.

Instructions to set these parameters on the Liebert FS are found in **6.5.3 - Control Parameters Setup at Initial System Startup**.

Multiple Liebert FS Parallel Operation—Regular Configuration

Liebert FS Software Control Parameters must be reset when multiple Liebert FS units are connected in parallel on the DC bus of a Liebert HiPulse™ UPS system for proper operation with longer run times or higher backup power requirements. The Liebert FS units will contribute all together at the same time to the task of supporting the UPS DC bus.

Instructions on setting these parameters on the Liebert FS are found in **6.5.3 - Control Parameters Setup at Initial System Startup**.

NOTE

In this configuration, the UPS DC bus usually does NOT have batteries in parallel with the Liebert FS units, however, parallel operation with batteries is acceptable. If batteries to be used are in parallel with the Liebert FS units on the UPS DC bus, contact your local Liebert sales representative to arrange a review of the application.

NOTE

Your Liebert-certified service technician will configure the Software Control Parameter values at Initial System Startup depending on the number of paralleled units.

APPENDIX B.0 DATA COLLECTION MODULE

Appendix B.1 General Information

Appendix B.1.1 Overview

The Data Collection Module (DCM) is designed to provide real-time data monitoring and data storage for the Liebert FS. The DCM collects data on virtually every event that occurs in the Liebert FS. Data such as speed, temperature and voltage are just a few of the data points that the DCM will be collecting and storing on its internal memory card. The DCM has an HTML interface, which means any Internet browser, such as Internet Explorer or Netscape, is all that is required to access the Liebert FS data.

Appendix B.1.2 Features

The DCM comes equipped with four (4) RS-232 communication ports and a 10/100 Base-T RJ-45 port. The DCM runs on the Linux operating system, which resides on the internal compact flash memory card. Dynamic Host Configuration Protocol (DHCP) has been enabled on the DCM to allow easy integration with an existing network.

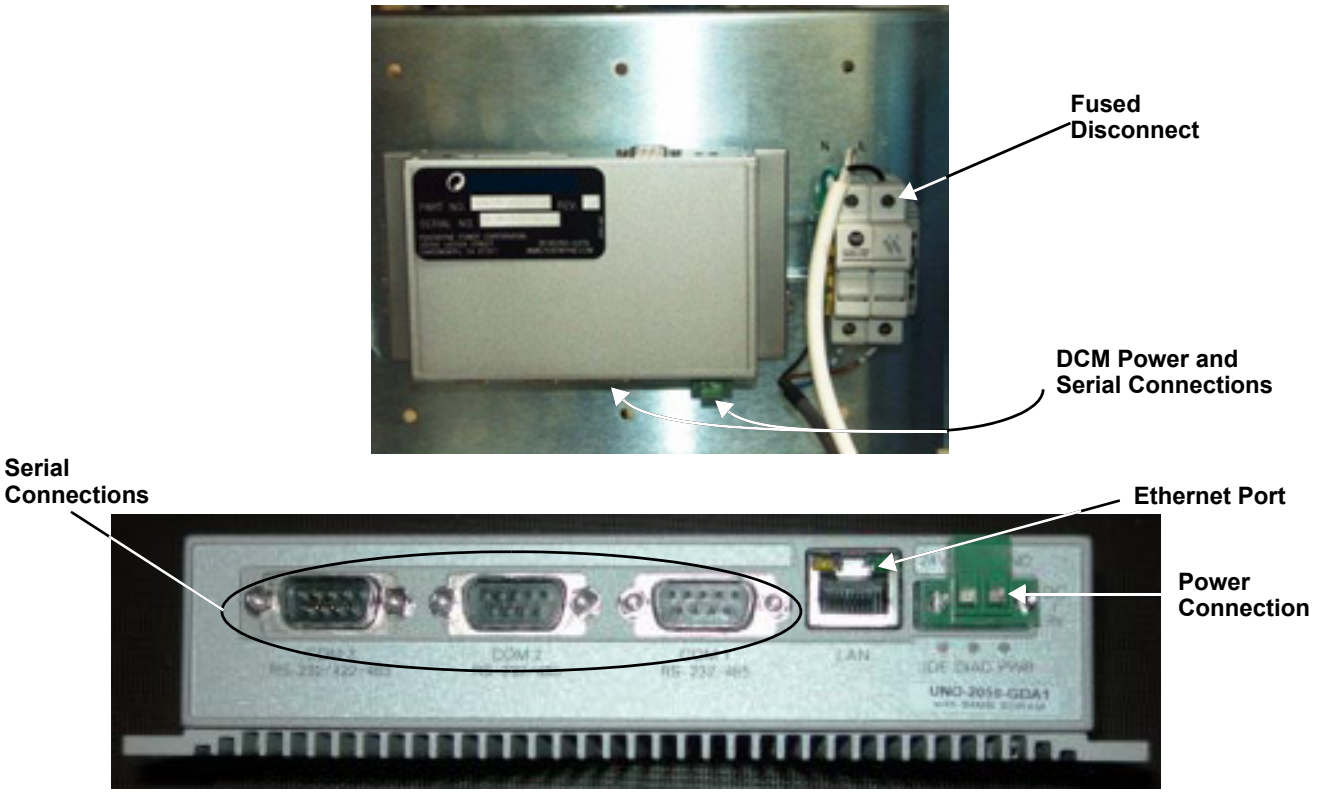
Appendix B.2 DCM Installation and Configuration

Appendix B.2.1 Installation

The DCM has been installed at the front of the Liebert FS inside the door on the service panel and has been securely mounted adjacent to the AC auxiliary fused disconnect. The power cable and the serial communication cable have been connected at the factory as seen in **Figure 104**.

The DCM has been installed on the inside door of the Liebert FS and has been securely mounted adjacent to the Control Panel. The power cable and the serial communication cable have been connected at the factory as seen in **Figure 104**.

Figure 104 Data Collection Module location, features

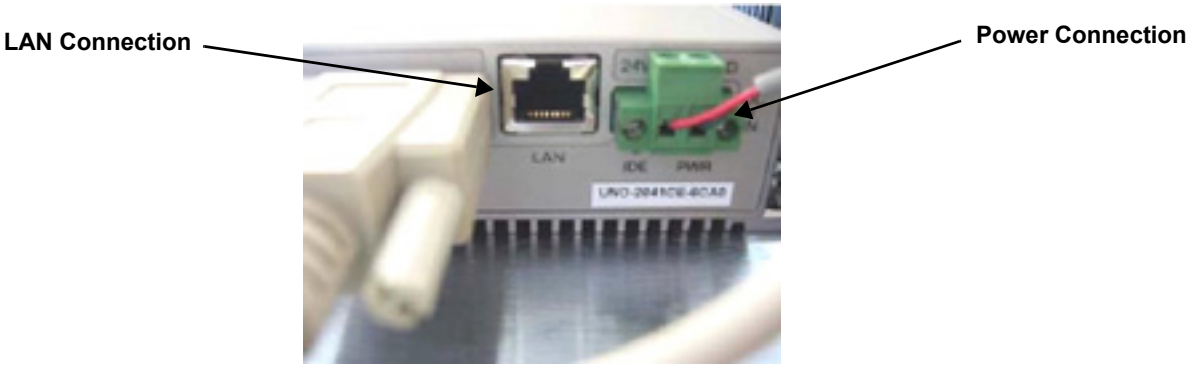


Appendix B.2.2 DCM Requirements

The Data Collection Module requires a connection to an existing network via an Ethernet cable. An RJ-45 jack is built directly into the bottom of the faceplate of the DCM and located adjacent to the power supply connection. The DCM may also be connected via modem through COM2 serial port.

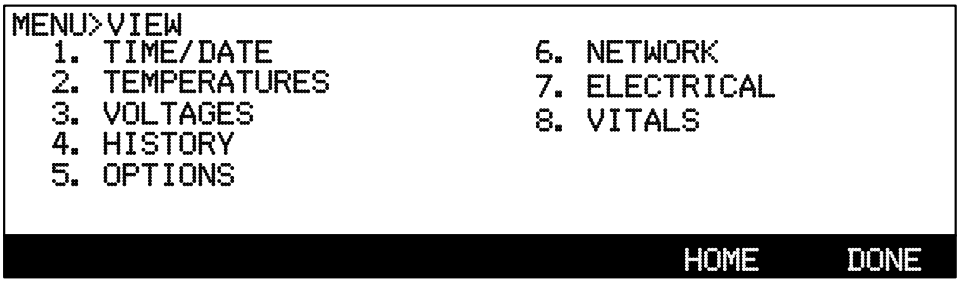
By connecting to your existing network with an Ethernet cable, you will be able to access the DCM via your Internet browser. **Figure 105** displays the LAN connection, which is located on the bottom side of the DCM.

Figure 105 DCM LAN connection



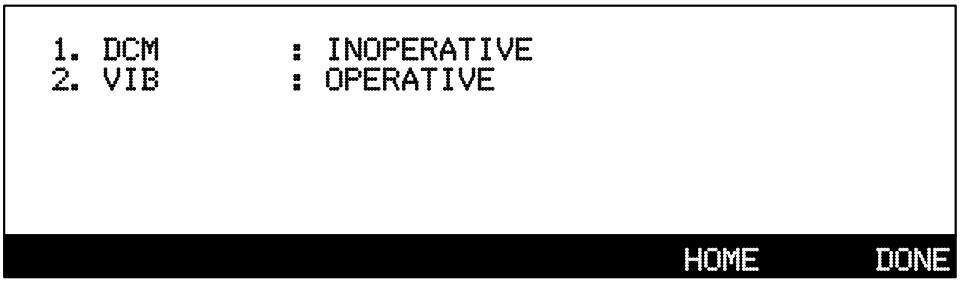
DHCP is enabled at the factory. A connected DHCP Server automatically assigns an IP Address to the DCM. To confirm that the DCM is enabled and operative, check the Liebert FS Control Panel. From the Main Menu Screen, select number 2 “View” screen.

Figure 106 Options view



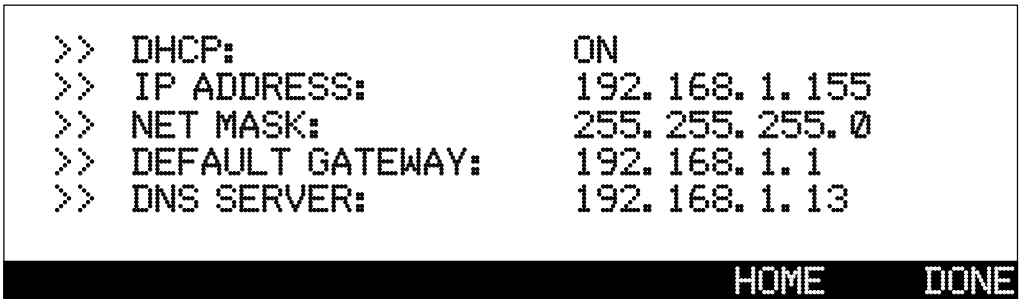
Select the number 5 “Options” screen to view the current status of the options. To enable or disable this option, select and press the number 1 for the DCM option. To exit this screen, press the F6 or “Done” key.

Figure 107 Enable or disable DCM



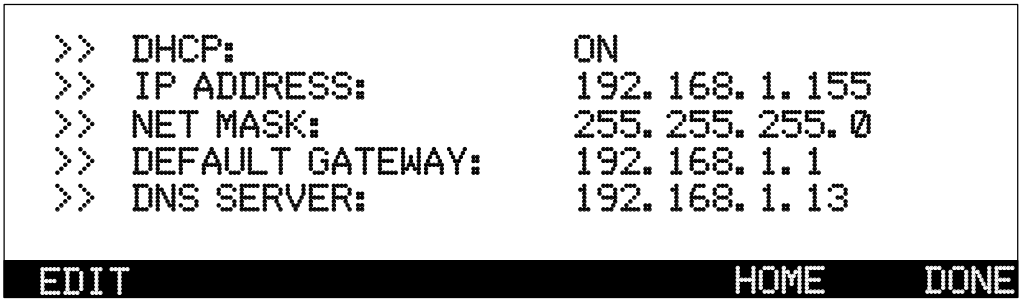
To view the Network settings return to the View menu and press number 6 “Network”. The Network view screen displays the network addresses coming from the DCM. Static address settings can be entered using the keypad into this screen. The Network screen will show the assigned IP Address, Default Gateway, Subnet Mask and DNS Server.

Figure 108 Networks view



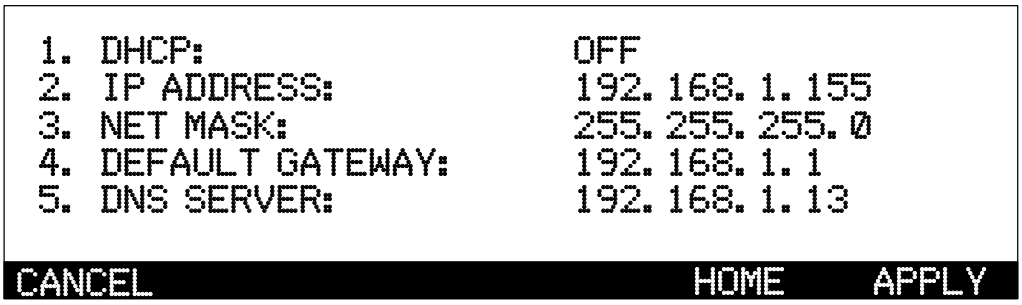
By entering a Password to access the User or Service level mode you can edit this function. Pressing the EDIT button, F1, will place the system in the edit mode. The DHCP must be disabled or turned Off to proceed with setting IP addresses and other settings. After pressing EDIT you will see up/down arrows next to the DHCP On value. Pressing the up or down arrows on the keypad will allow you to turn this function Off or On.

Figure 109 Networks view, turn off DHCP



Once you have turned DHCP OFF, press EDIT again and now you will see numbers next to each of the settings. Pressing the corresponding number will allow you to enter or change that value. At any time you may press CANCEL to cancel the changes, once changes or entries are complete, press APPLY to complete entry process. Pressing APPLY will reboot system and in a few minutes the system will display the new screen.

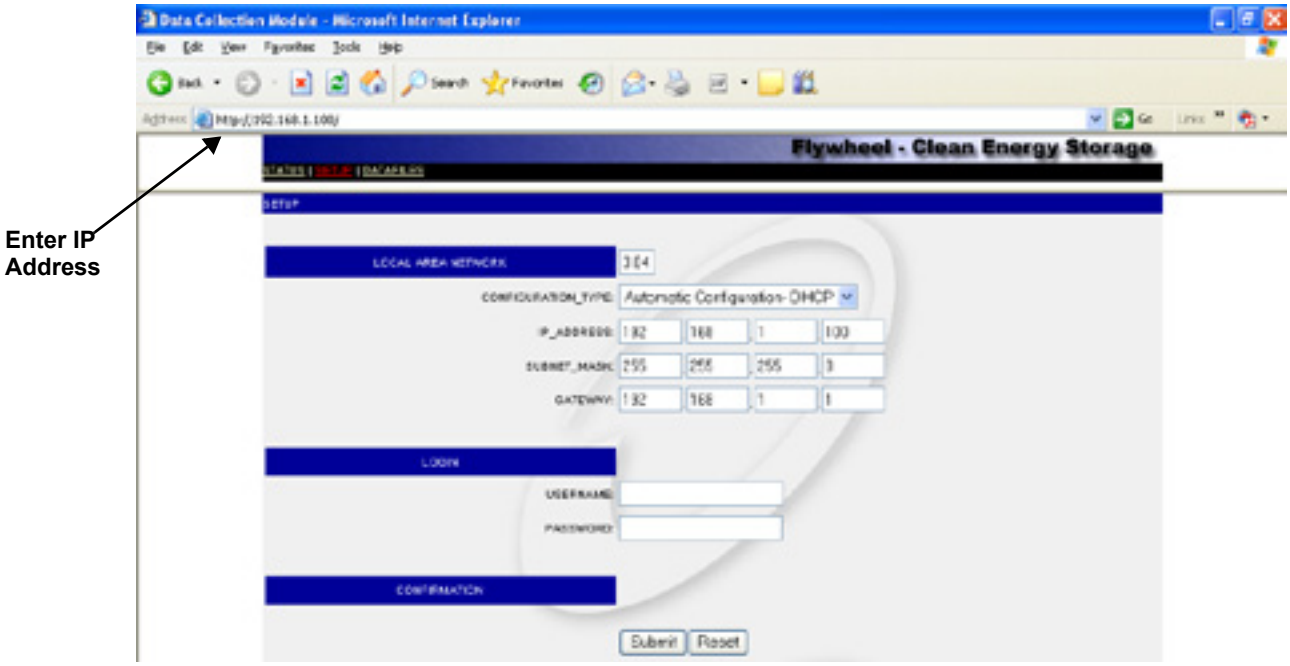
Figure 110 Networks view, edit settings (service level)



Appendix B.2.3 Accessing the DCM

From a personal computer connected to the same network as the DCM, enter the IP Address of the DCM, assigned by the LAN network server or manually configured, into the address line of the Internet browser to gain access to the DCM as seen in **Figure 111**.

Figure 111 DCM screen



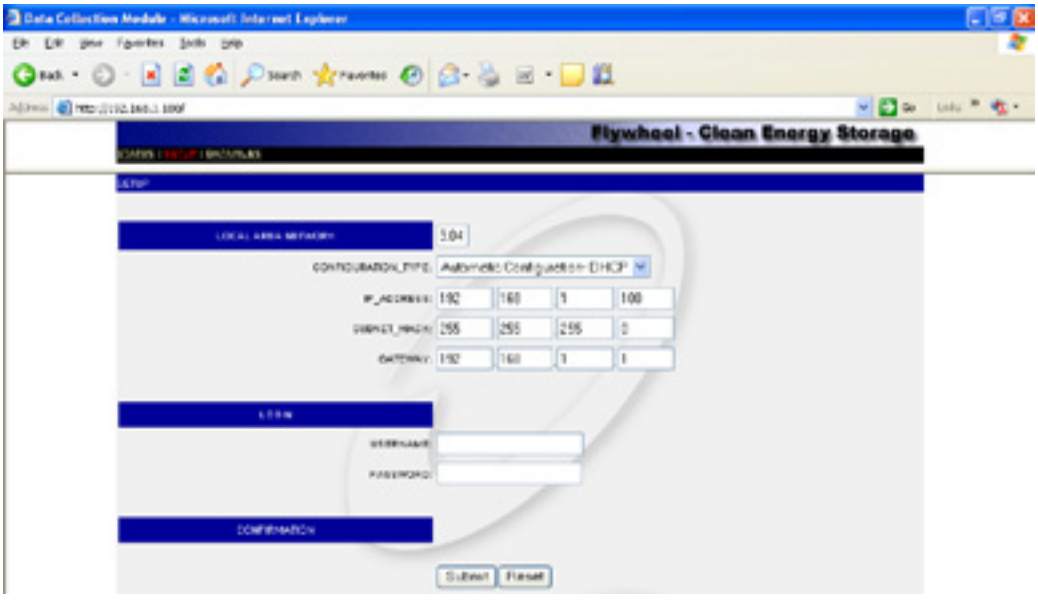
The DCM software has a screen menu bar along the top of the page. Three screens may be accessed: STATUS, SETUP and DATAFILES. The screens allow for setup of the DCM and different ways to browse the data recorded by the DCM.

Appendix B.2.4 Configuring DCM System Parameters

One of the tabs in the menu bar is the DCM system "Setup" page. This page will allow you to customize your DCM settings. For example, you may want to assign a static IP Address to the DCM. There are seven fields on the Setup page as seen in **Figure 112**. Enter data in the fields and once you are done with entries, click the Submit button to enter changes or click Reset to reset the DCM.

The default Username and Password for setup are "hello" and "hello" respectively. Liebert recommends changing both the username and password to prevent unauthorized changes to the system.

Figure 112 DCM setup screen



- **Software Version:** The current version of the software running on the DCM.
- **Configuration Type:** Select from the drop-down menu as to whether it is a Static IP Address or a DHCP server assigned.
- **IPAddress:** The IP Address of the DCM
- **Subnet Mask:** The Subnet mask of the DCM
- **Gateway:** The Gateway of the DCM
- **User:** The user name to gain access to the DCM.
- **Password:** The password to gain access to the DCM.

If a parameter setting needs to be changed (i.e., dynamic IP to static IP), please consult your network administrator for the correct parameters. To save any changes, click the Submit button. The DCM will automatically reboot itself. You will need to reconnect to the DCM through the browser.

Appendix B.3 DCM Operation

Upon Initial System Startup of the Liebert FS by a Liebert-certified service technician, the DCM will be operational. There is nothing to turn on or configure.

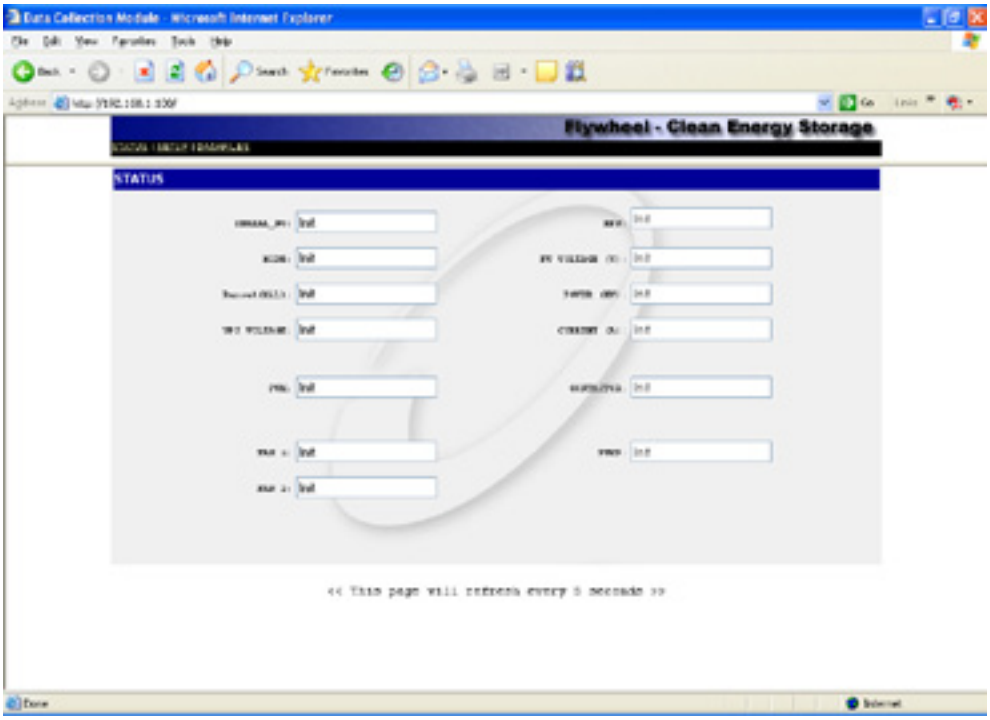
Appendix B.3.1 Logging into the DCM

Enter the IP Address into the address line of the Internet browser to gain access to the DCM as shown in **Figure 111**. The DCM's IP Address is described in **Appendix B.2 - DCM Installation and Configuration**. The first page that appears is the Status Page.

Appendix B.3.2 Status and Detailed Status Screens

The Status page displays various data points from the Liebert FS as shown in **Figure 113**. Data is refreshed approximately every five (5) seconds.

Figure 113 DCM status screen



The Status page provides basic system operational data, all data normally found on the Main Screen of the system Control Panel, such as Mode, RPM and Power.

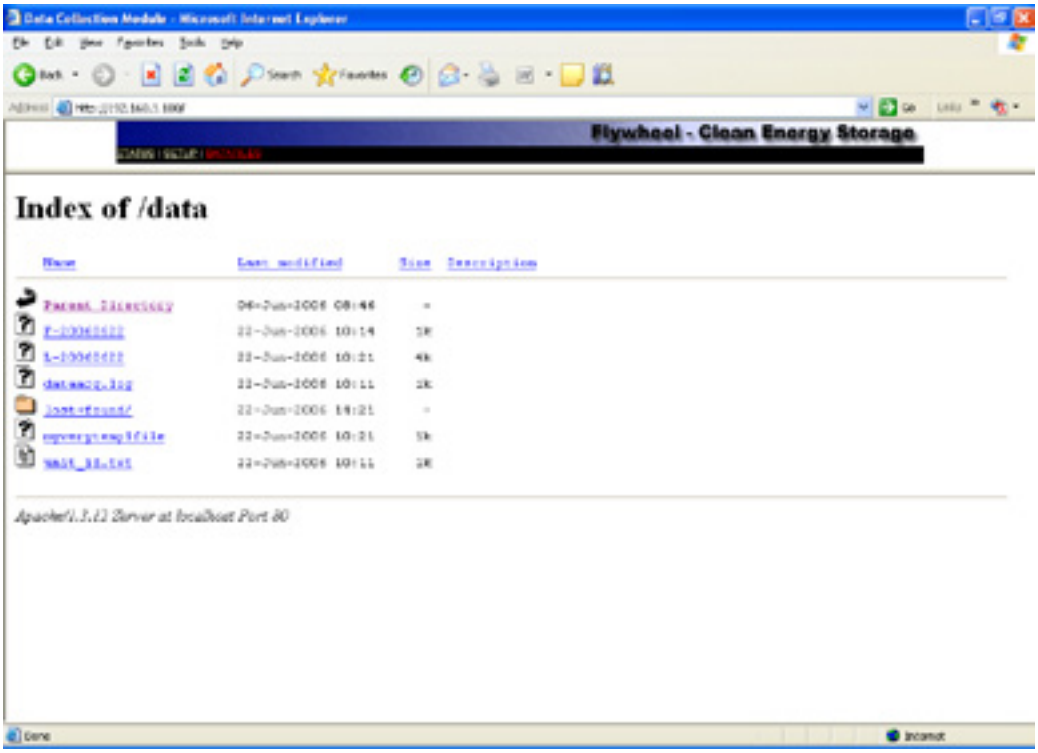
The Status screen provides more detailed information on system characteristics, such as Serial No., and performance. This includes real time information on voltages and temperatures in the system.

Appendix B.3.3 Datafiles Screen

This screen lists the different files types for viewing and download. There are five files types: F, S, L, A and D.

- **F** indicates a fast data packet, containing electrical information such as voltages, amps and watts.
- **S** represents a slow packet for measurements collected over a longer period, such as temperatures.
- **L** stands for Log files and these contain information on system modes, statuses and commands.
- **A** indicates an alarm file and will contain information on any Faults or Warnings recorded.
- **D** files indicate a system discharge and allow a user to view the time, duration and amount of Discharge.

Figure 114 Datafiles screen



Appendix B.4 DCM Troubleshooting

Appendix B.4.1 DCM Troubleshooting Principles

There are few circumstances in which the Liebert FS might operate in an unexpected manner. This section explains a few of these circumstances and offers some solutions to such issues.

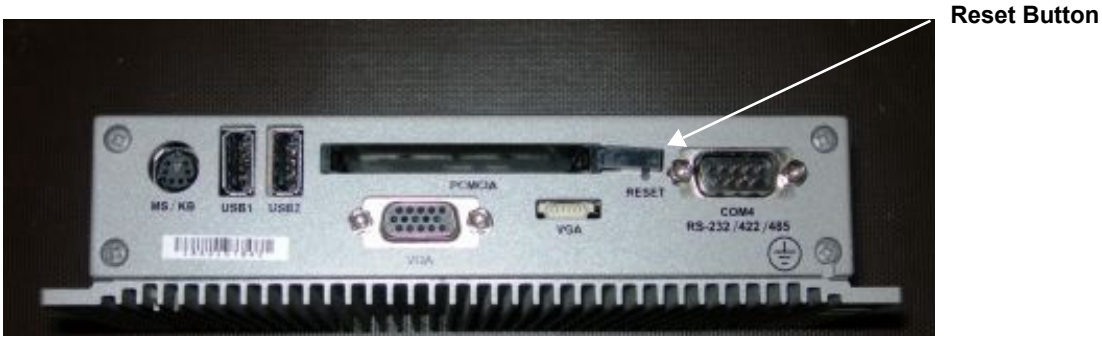
Table 33 Troubleshooting

What You See…	What It Means…	What To Do…
A gray windows appears in the Web browser when connecting to the DCM	The HTML page is not loading properly	Ensure that the correct IP address is entered and or check with IT administrator
Cannot connect to specified address	The DCM is not online or connect to the network	Verify that the Ethernet cable is securely connected to the DCM

Appendix B.4.2 Resetting the DCM

If the DCM requires rebooting, use a small object, such as a paperclip, to press the reset button, shown in **Figure 115**. The reset button is marked RST. It is adjacent to the RS-232 COM2 Port. The DCM will emit a series of beeps if the DCM is reset. Allow a minimum of 90 seconds for a complete reboot before attempting to connect to the DCM.

Figure 115 Data Collection Module reset button



APPENDIX C.0 VERSATILE INTERFACE BOARD

Appendix C.1 General Information—Versatile Interface Board

Appendix C.1.1 Versatile Interface Board Overview

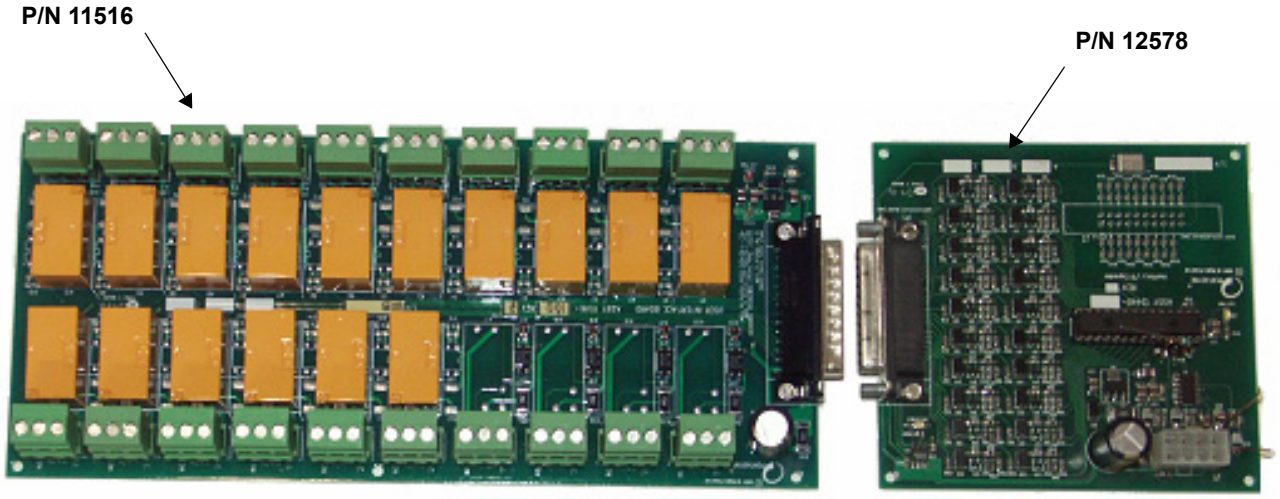
The Versatile Interface Board (VIB) is designed to provide real-time status feedback and control of the Liebert FS. The VIB has 16 digital outputs (isolated, dry Form C contacts) and three digital inputs (optical isolator) that provide the user with information about the operational mode and state of charge of the Liebert FS, as well as the ability for the user to start the system, stop the system and clear alarms.

The VIB consists of the following components:

- 12578 - Auxiliary I/O Interface Board
- 11516 - User Interface Board (UIB)
- 12781 - Cable Assembly
- Mounting hardware

Figure 116 shows the two main electrical components of the VIB.

Figure 116 VIB components



Appendix C.1.2 VIB Features

The VIB provides fully isolated inputs and outputs that operate on a wide range of voltages for maximum flexibility. Each I/O is programmed to perform a dedicated function. The specific function of each I/O is listed below in **Table 34**.

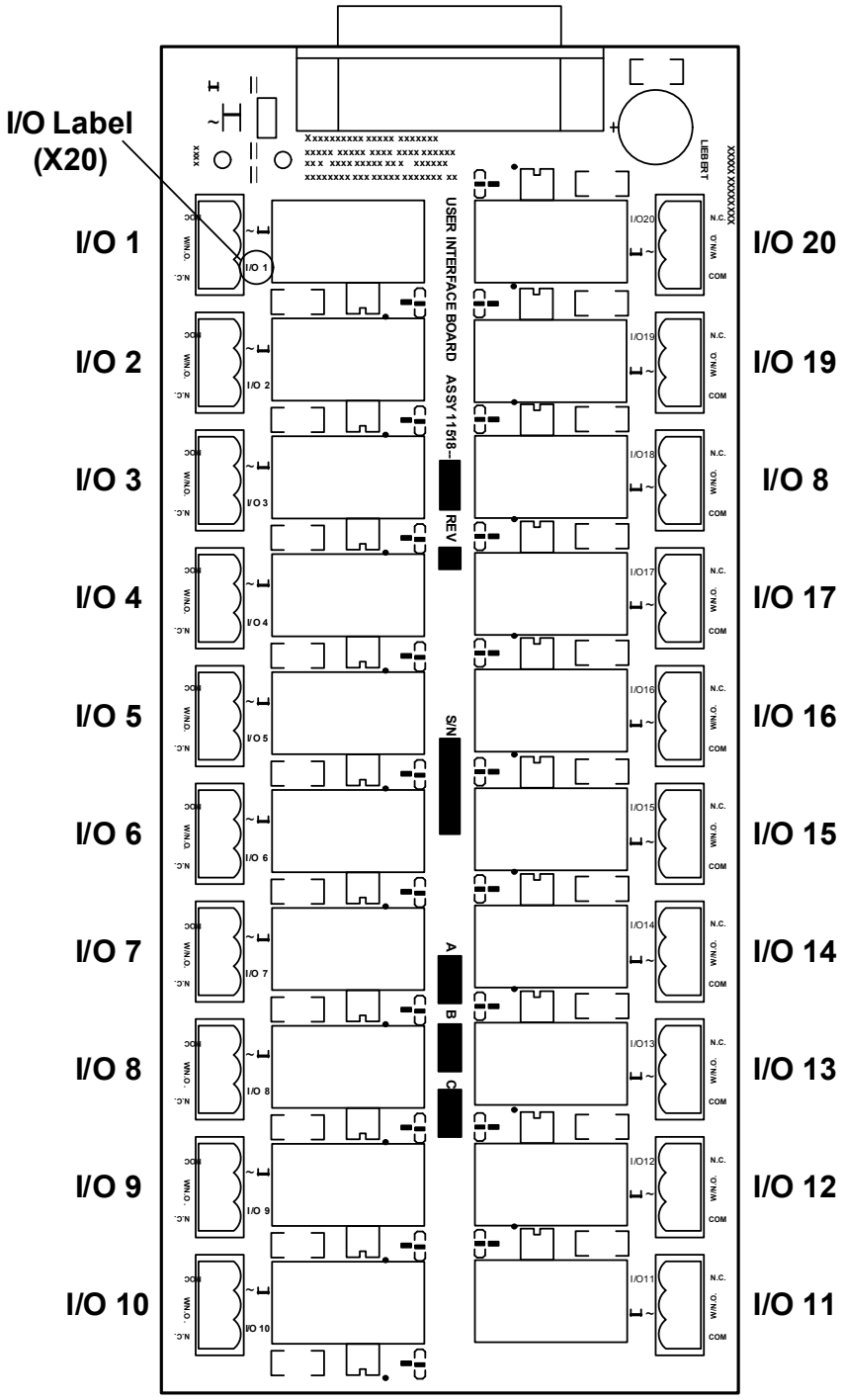
Table 34 VIB I/O functions

I/O	Interface	VIB Designation	Description
1	Output 1	Off[1]	Mode = Off (RPM < 200)
2	Output 2	Startup	Mode = Startup (200 < RPM < 25000)
3	Output 3	Charge	Mode = Charge (RPM > 25000)
4	Output 4	SOC >= 0%	State of Charge >= 0%
5	Output 5	SOC >= 12.5%	State of Charge >= 12.5%
6	Output 6	SOC >= 25%	State of Charge >= 25%
7	Output 7	SOC >= 37.5%	State of Charge >= 37.5%
8	Output 8	SOC >= 50%	State of Charge >= 50%
9	Output 9	SOC >= 62.5%	State of Charge >= 62.5%
10	Output 10	SOC >= 75%	State of Charge >= 75%
11	Output 11	SOC >= 87.5%	State of Charge >= 87.5%
12	Output 12	Ready	Mode = Ready (SOC >= 99%)
13	Output 13	Discharge	Mode = Discharge
14	Output 14	Shutdown	Mode = Shutdown
15	Output 15	Warning	Mode = Warning
16	Output 16	Fault	Mode = Fault
17	Input 1	Start[2]	Start Command Issued
18	Input 2	Shutdown[2]	Shutdown Command Issued
19	Input 3	Clear Fault	Clear Fault Command Issued
20	Output 17	Rotor Temp	Rotor Temp High

1. The “OFF” signal is also used to indicate if the temperature of the rotor is too warm. If the “OFF” output is asserted while any of the other “Mode” outputs are asserted (STARTUP, CHARGE, SHUTDOWN, DISCHARGE) or while the State of Charge is >= 0%, then the rotor is too warm and must cool before charge resumes.
2. “START” and “SHUTDOWN” inputs are mutually exclusive. If they are asserted simultaneously, both will be ignored.

For reference, the I/O designations are shown in **Figure 117**. The number of each I/O is also labeled on the circuit board.

Figure 117 I/O Designations



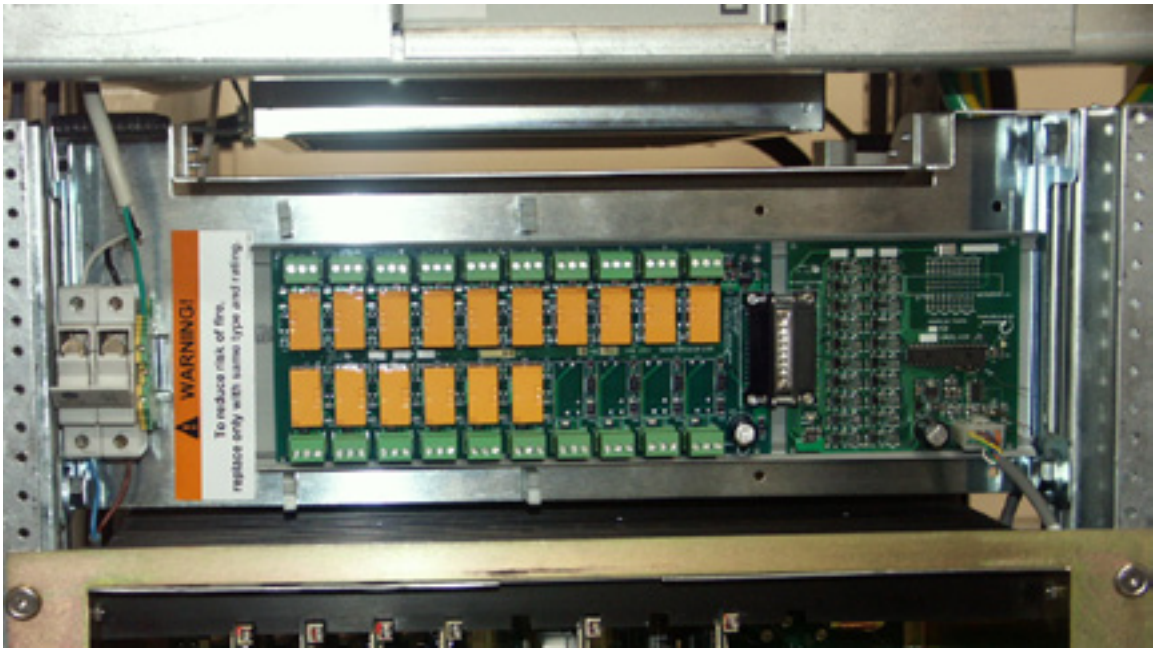
Appendix C.2 VIB Installation and Configuration

Appendix C.2.1 VIB Installation

The VIB has been installed behind the service panel of the Liebert FS. The power/communications cable has been connected to the Main Control Module at the factory.

NOTE
If The VIB option has been purchased separately, refer to the installation instructions included with the kit for the proper mounting procedure.)

Figure 118 Versatile Interface Board mounted in the Liebert FS



Appendix C.2.2 VIB Requirements

The VIB requires software version 2.09 or later to operate properly. To verify the software version, press F6 from the main screen of the display panel. The software version is displayed in the lower left corner of the display. Press F6 when finished.

Appendix C.2.3 VIB Input Specifications

- Opto-isolated inputs, active high.
- Minimum Trigger Voltage: 3.5V DC (“IN” relative to “COM”).
- Maximum Operating Voltage: 32V DC (“IN” relative to “COM”).
- Minimum Input Current: 5mA DC.
- Inputs must be present for at least 200ms to be recognized as valid signals.
- Each input has a green status LED to indicate assertion of the signal.

Appendix C.2.4 VIB Output Specifications

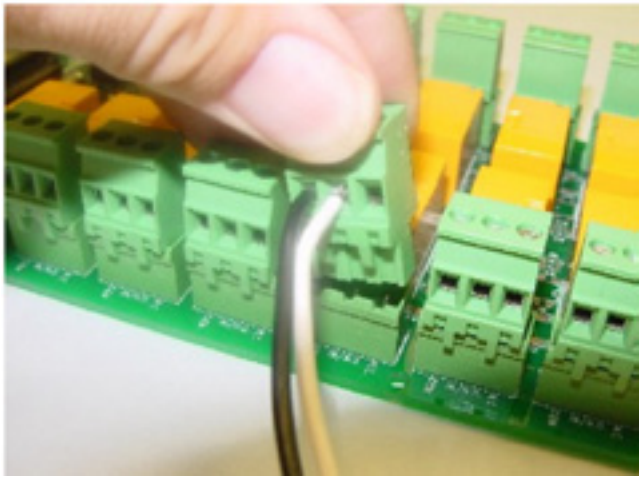
- Dry contact Form C relay: Normally Open (NO), Normally Closed (NC) and Common (COM) outputs available.
- Maximum Contact Resistance: 50mΩ
- Minimum Insulation Resistance: 100MΩ at 500V DC
- Maximum Switching Power: 500VA, 90W
- Maximum Switching Voltage: 250V AC, 30V DC
- Maximum Switching Current: 2A AC, 3A DC
- Minimum Life: 100,000 operations on resistive loads
- Each output has a green status LED to indicate assertion of the signal

Appendix C.2.5 VIB Connections

The VIB is supplied with removable screw-terminal connectors to allow for easy integration **Figure 119**. The user must supply the wire as specified below to make the connections to the VIB connectors.

- Wire gauge: 12-24 AWG
- Stripped length: 0.125" - 0.250"
- Tightening torque: 4.4 inch-pounds (maximum)

Figure 119 VIB screw terminal connections



Appendix C.3 VIB Operation

Upon Initial System Startup of the Liebert FS by a Liebert-certified service technician, your VIB will be operational. There is nothing to turn on or configure. Make sure that all external connections to the VIB are made with the Liebert FS power off. Making connections while power is applied may have undesirable effects and may damage the equipment.

Appendix C.3.1 VIB Operational States

The operational status of the VIB is indicated on the main screen of the Display Panel. There are three possible states: “Enabled”, “Disabled” and “Not Available”. They are indicated on the Display Panel by “1,” “0” or “NA,” respectively.

“Enabled” State

If the VIB is detected when the system is powered-up or rebooted, it will automatically be enabled. If for any reason the VIB has been disabled, it can be re-enabled by pressing F6 (Setup Parameters), then F3 (UIB Enable). While the VIB is enabled, the “Start,” “Stop” and “Clear Fault” buttons will not be visible on the Display Panel. To control the Liebert FS from the Display Panel, the VIB must first be disabled.

“Disabled” State

If the VIB is not detected when the system is powered-up or rebooted, it will automatically be disabled. At any time during operation the VIB can be disabled by pressing **F6** (Setup Parameters), then **F3** (UIB Disable). When the VIB is disabled, the inputs are ignored and all outputs are turned off. Before disabling the VIB, consider how disabling the board will affect other system components.

“Not Available” State

The Liebert FS continually monitors the status of the VIB to verify that it is operating correctly. If the response from the VIB is not what is expected by the Liebert FS, “WARNING” will be displayed on the front panel.

Appendix C.4 Troubleshooting the VIB

Appendix C.4.1 UIB State Not Displayed on the Front Panel

- Check that no other faults are present on the display panel.
- Call Liebert for instructions on how to enable the VIB functionality.

Appendix C.4.2 VIB in "Disabled" or "Not Available" State

- Attempt to enable the VIB by pressing **F6** (Setup Parameters), then **F3** (UIB Enable).
- Verify that the cable to the VIB is plugged in properly.
- Verify power is present on the Auxiliary I/O board. This is indicated by illumination of LED "LD2".
- Verify power is provided to the UIB. This is indicated by illumination of "LD1" on the Auxiliary I/O board and "LD21Pentagon on the UIB. Note that "LD2"on the Auxiliary I/O board will be illuminated only if the UIB is connected.
- Check the continuity of the cable from pin to pin.

Appendix C.4.3 Inputs Not Recognized

- Verify power is present at the VIB.
- Verify the VIB is enabled on the display panel.
- Verify that the proper voltage is being supplied to the input.
- Verify that the LED indicator corresponding to the input illuminates when the input signal is applied.

Appendix C.4.4 Outputs Not Asserted

- Verify power is present at the VIB.
- Verify the VIB is enabled on the display panel.
- Verify that the LED indicator corresponding to the output illuminates when the output is asserted.

APPENDIX D.0 INSTALLATION DRAWINGS

Appendix D.1 Liebert FS Flywheel Submittal Document Matrix

Following is a list of submittal documents that must accompany each Liebert FS that ships from the factory. The documents are grouped by Liebert FS model number.

Table 35 Submittal documents accompanying Liebert FS

Liebert FS Model Number: 25FS19ES0000; Liebert Series 300 Flywheel Storage Solution	Liebert FS Model Number: 37FS19ES0000; Liebert NPower Flywheel Storage Solution	Liebert FS Model Number: 39FS19ES0000; Liebert Series 610/600T/ 600 Flywheel Storage Solution
12-100120-00	12-100120-00	12-100120-00
12-100120-02	12-100120-01	12-100120-03
12-100120-08	12-100120-08	12-100120-04
12-100120-09	12-100120-09	12-100120-08
12-100120-10	12-100120-10	12-100120-09
12-100120-11	12-100120-11	12-100120-11
12-100120-12	12-100120-12	12-100120-12
12-100120-13	12-100120-13	12-100120-13
12-100120-14	12-100120-14	12-100120-14
12-100120-16	12-100120-16	12-100120-16
12-100120-17	12-100120-17	12-100120-17
12-100120-18	12-100120-18	12-100120-18
12-100120-20	12-100120-19	12-100120-20
12-100120-21	12-100120-20	12-100120-21
12-100120-22	12-100120-21	12-100120-22
Control_WL_S300	12-100120-22	Control_WL_S610
—	Control_WL_NPower	—

Appendix D.2 Other Liebert FS Drawings

Following is a list of additional Liebert FS drawings that are available for distribution. These drawings are not directly linked to any specific Liebert FS model number, because most of them are applicable to Liebert FS cabinets connected in parallel and we do not have a unique model number to identify such units.

Parallel Liebert FS Cabinets – Two - Three Cabinets, no DC Junction Box

- 12-100120-04 – Control Wiring, Liebert Series 610, 600T, 600, 300
- 12-100120-14 – One Line Diagram
- 12-100120-10 – Control Wiring, Paralleled Units
- 12-100120-20 – One Line Diagram, Paralleled Units

Parallel Liebert FS Cabinets – Four-Eight Cabinets with DC Junction Box

- 12-100120-17 – One Line Diagram
- 12-100120-10 – Control Wiring, Paralleled Units
- 12-100120-20 – One Line Diagram, Paralleled Units

Single Liebert FS Cabinets – Additional Elevation Drawings

- 12-100120-11 – Liebert FS Custom Configuration without Circuit Breaker

Figure 120 No UVR, circuit breaker to terminal block wiring

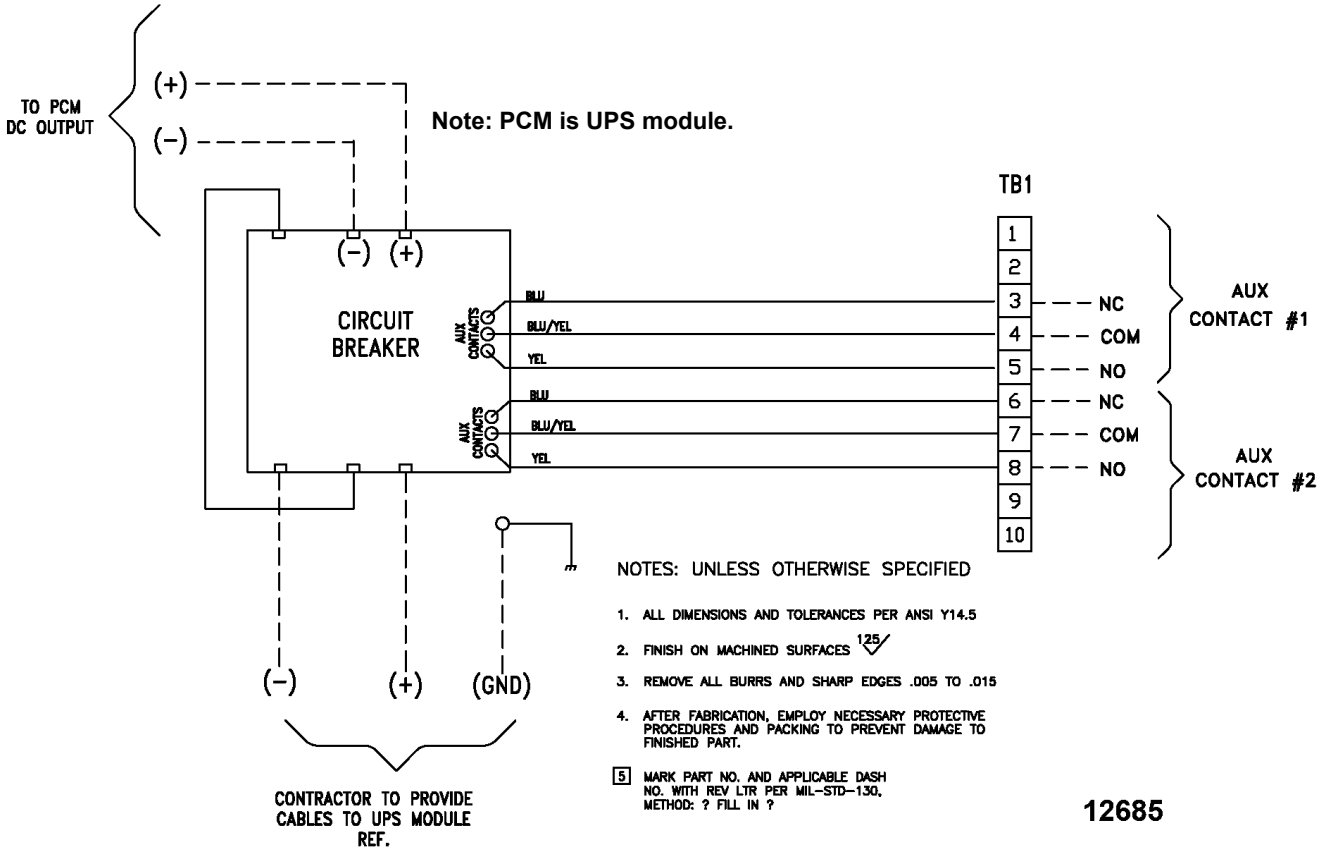
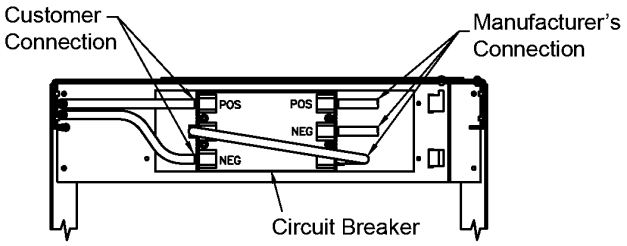


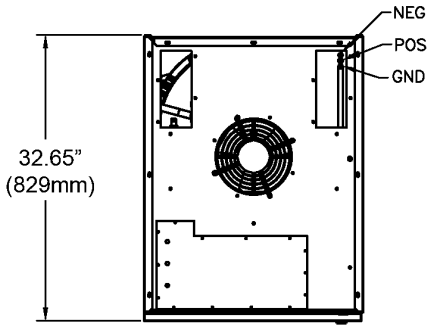
Figure 121 Electrical connections

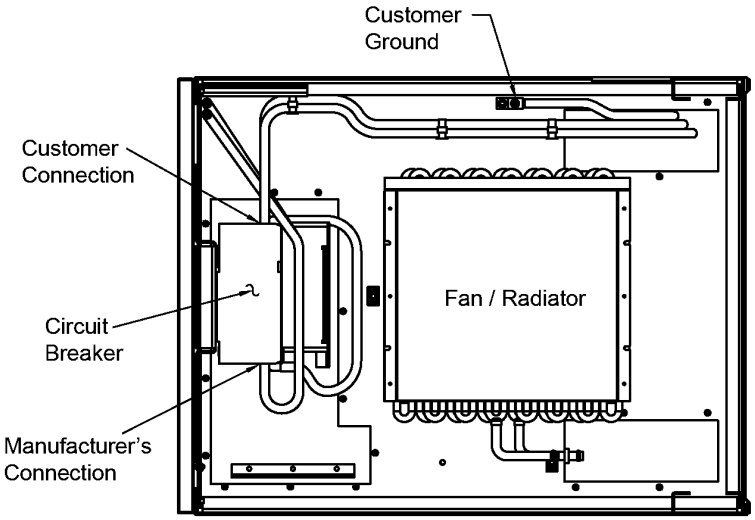
NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIMENSIONS AND TOLERANCES PER ANSI Y14.5
2. DIMENSIONS AND VALUES IN BRACKETS [ ] ARE METRIC, FOR REFERENCE ONLY
3. FINISH ON MACHINE SURFACES 125 [3.2]
4. REMOVE ALL BURRS AND SHARP EDGES .005 [0.13] TO .015 [0.38]
5. AFTER FABRICATION, EMPLOY NECESSARY PROTECTIVE PROCEDURES AND PACKING TO PREVENT DAMAGE TO FINISHED PART
6. MARK PART NO AND APPLICABLE DASH NO WITH REV LTR PER MIL-STD-130, METHOD: TAG

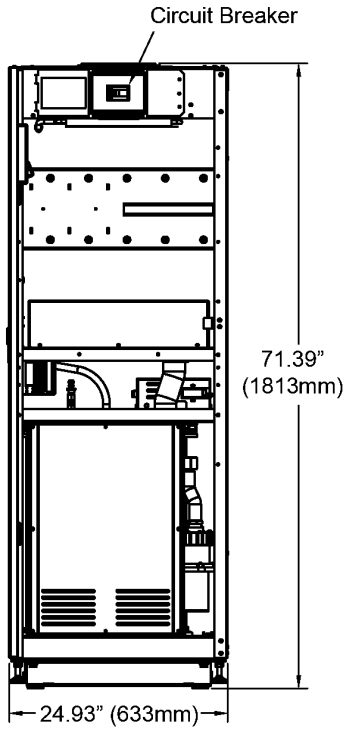


Section A-A Scale: 2/1

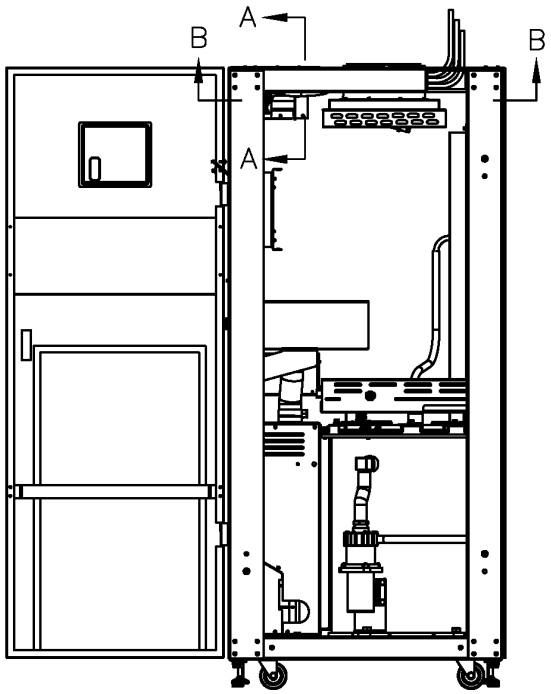




Section B-B Scale: 2/1



FRONT VIEW
DOOR OPEN



SIDE VIEW
SIDE PANEL REMOVED

14681

Figure 122 Electrical system block diagram

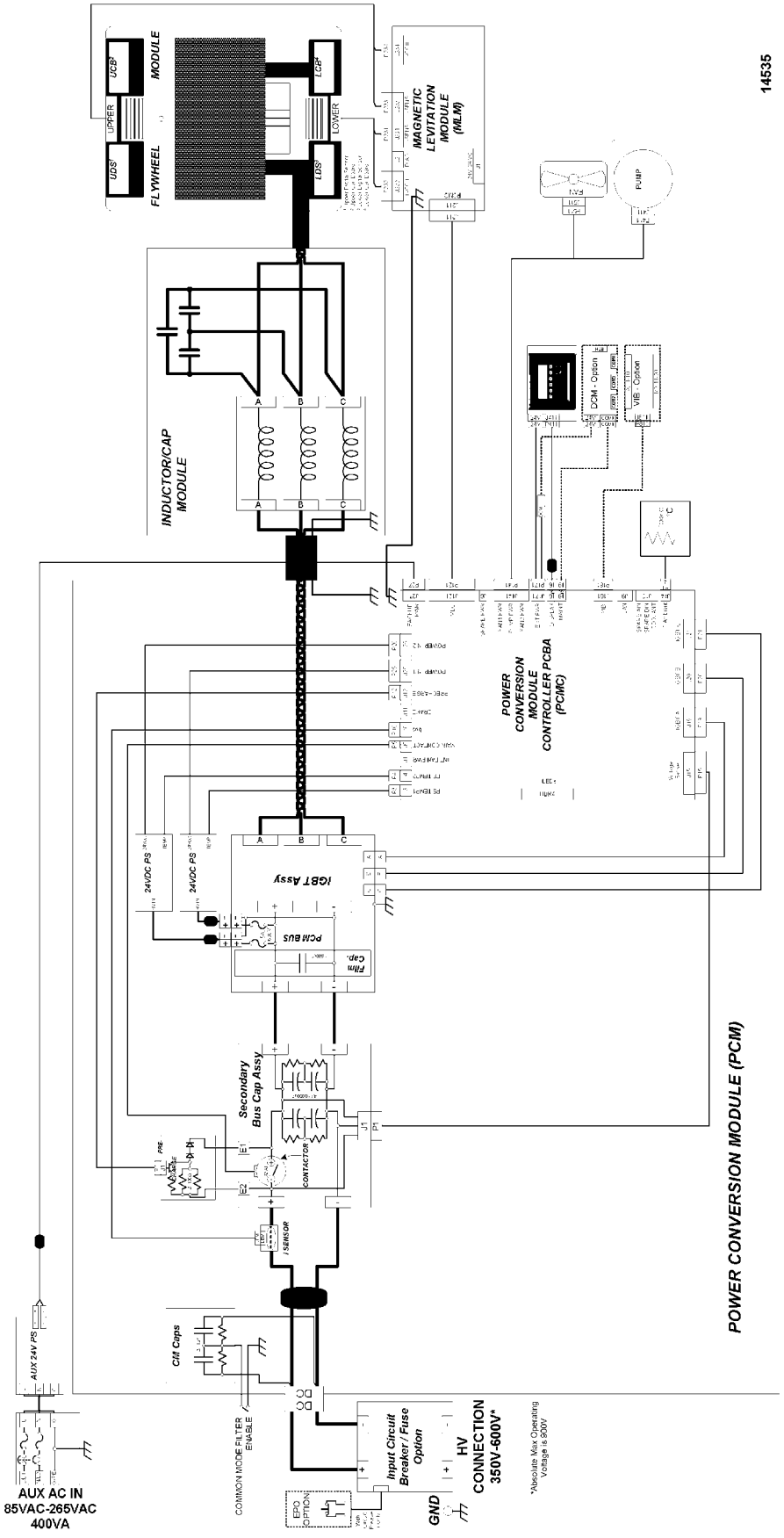


Figure 123 24 UVR, circuit breaker to terminal block wiring

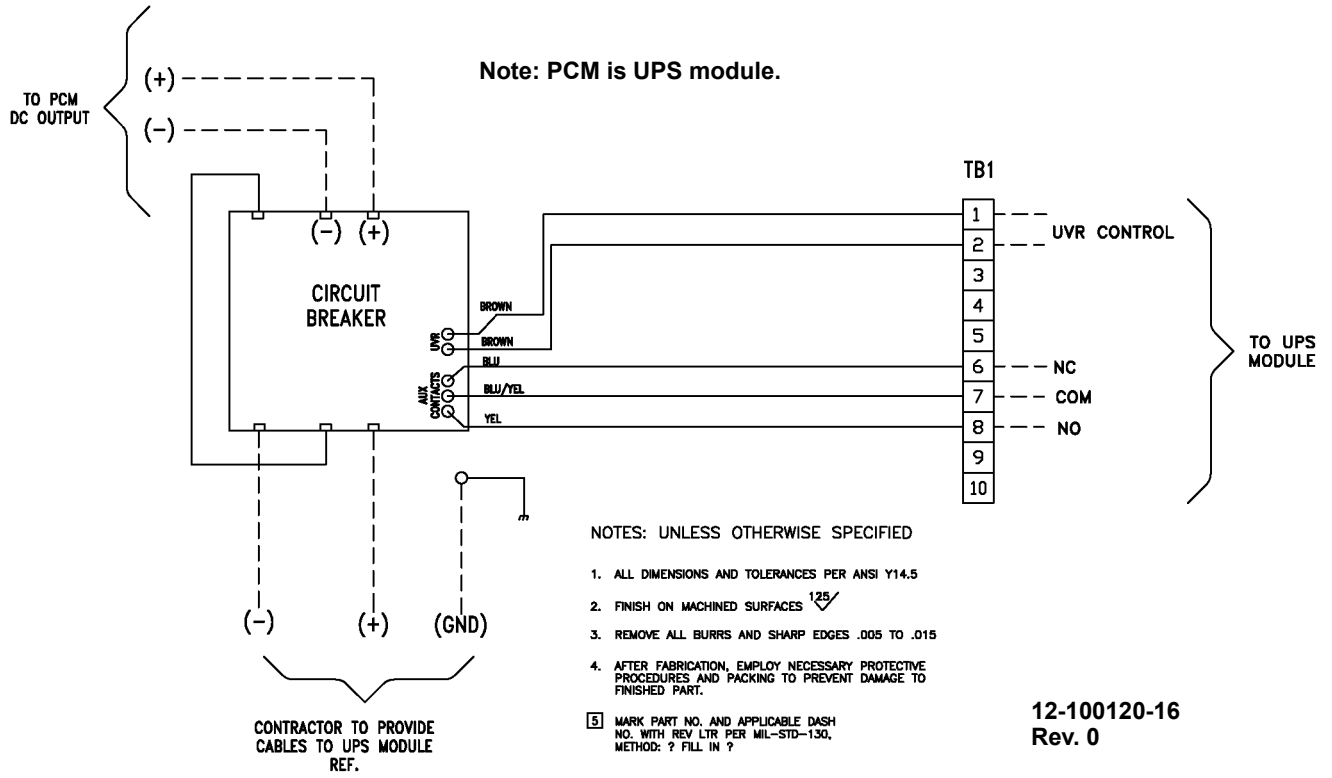


Figure 124 48 UVR, circuit breaker to terminal block wiring

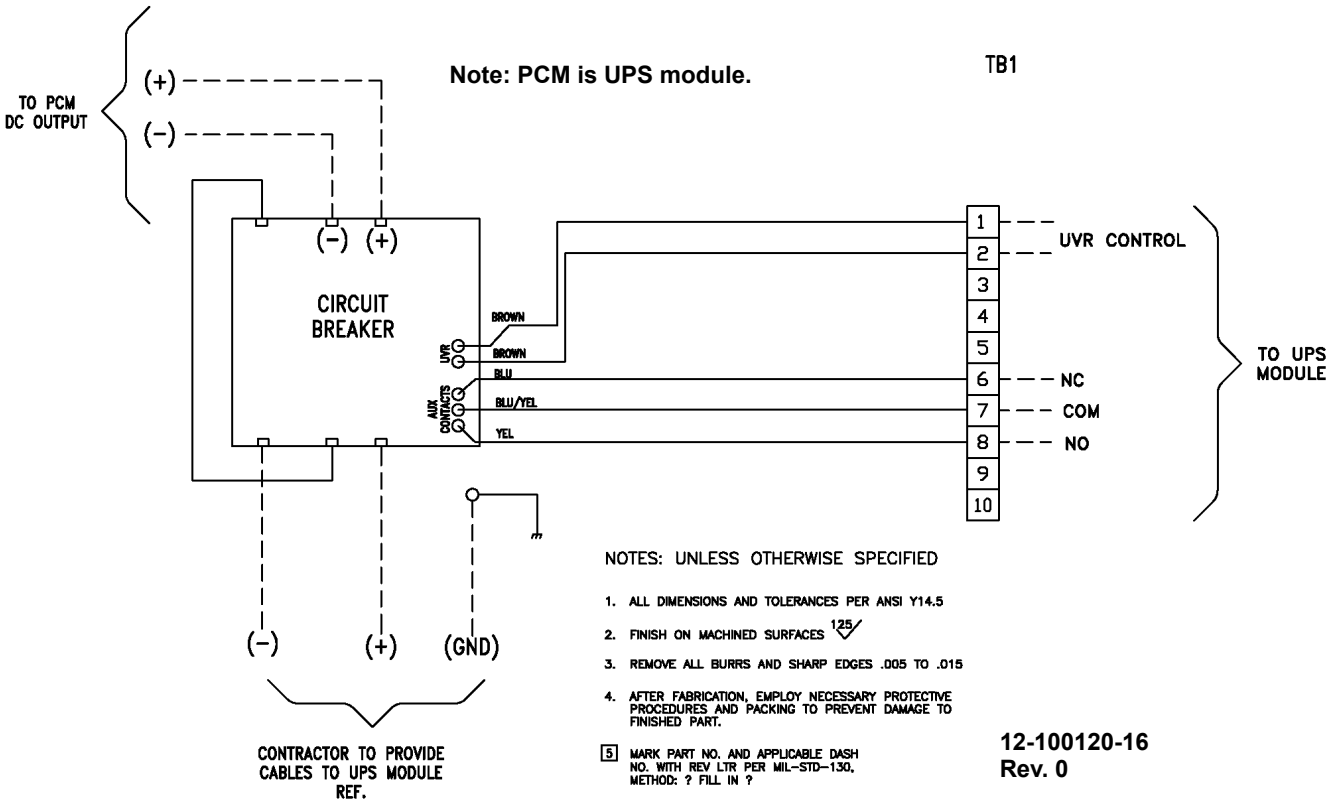


Figure 125 Outline drawing, Liebert FS cabinet

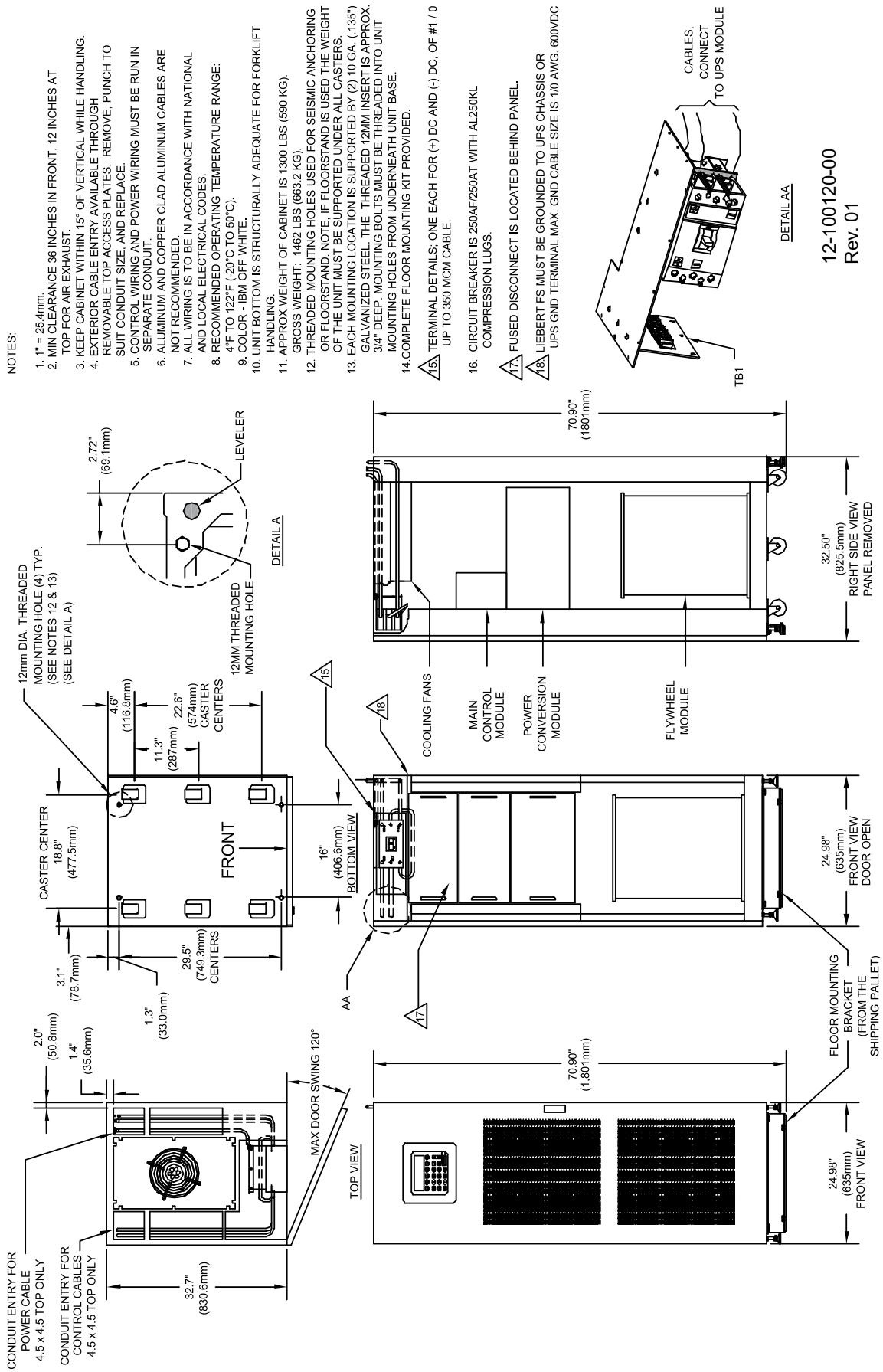


Figure 126 Control wiring, external interconnect diagram—Liebert FS cabinet to Liebert Npower UPS module

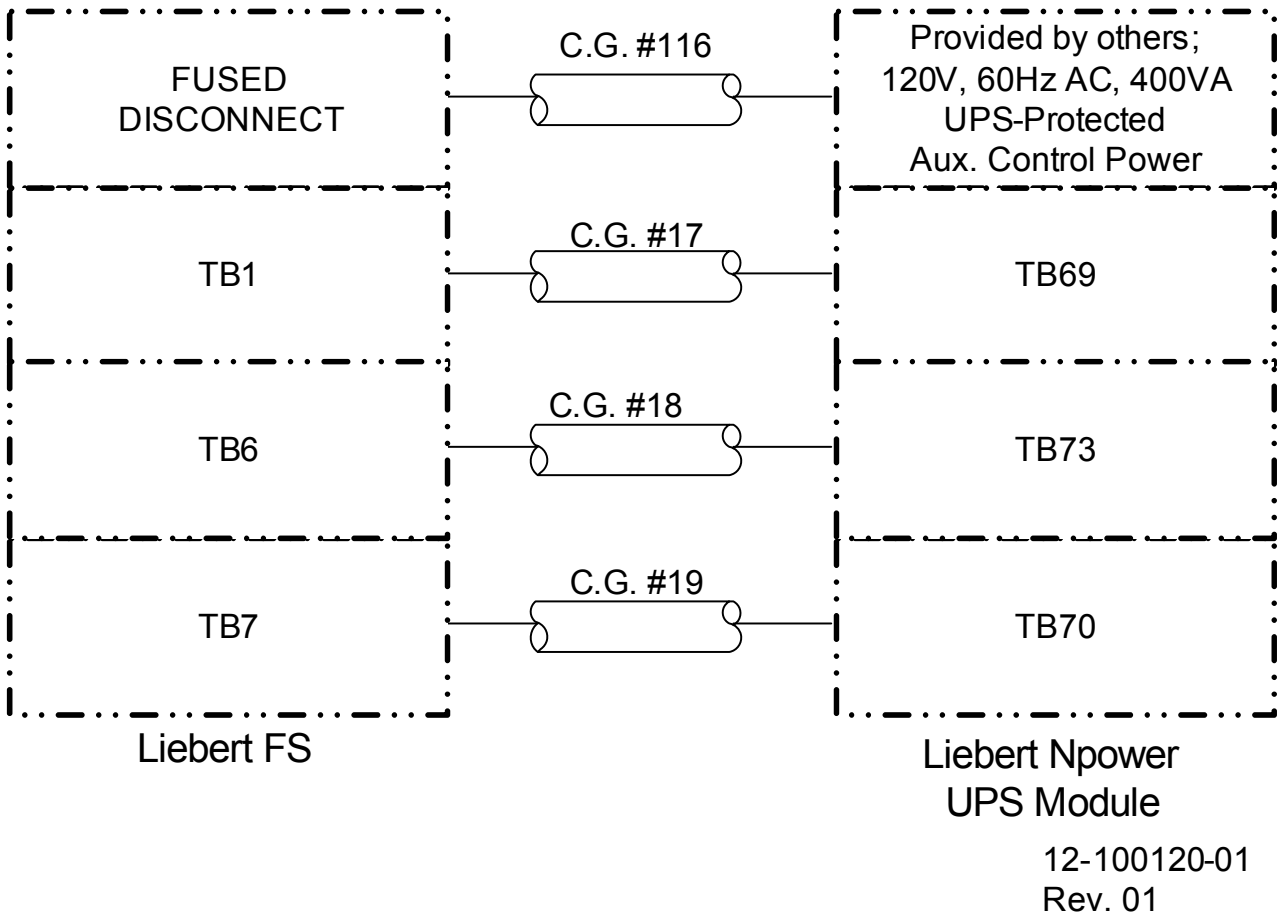


Figure 127 Control wiring external interconnect—Liebert FS to Liebert Series 300

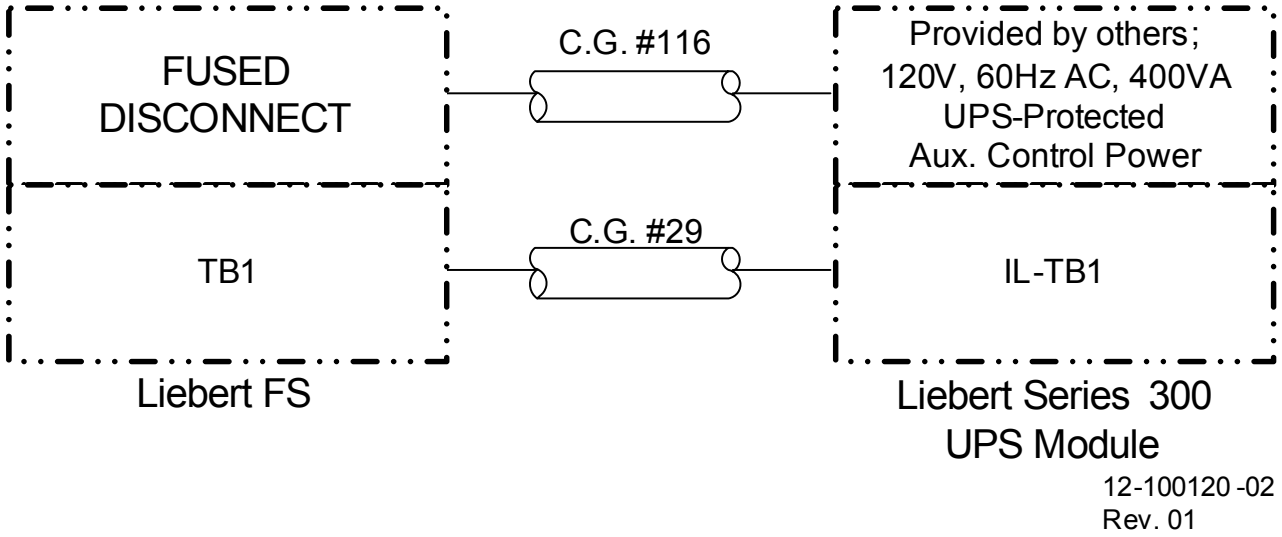
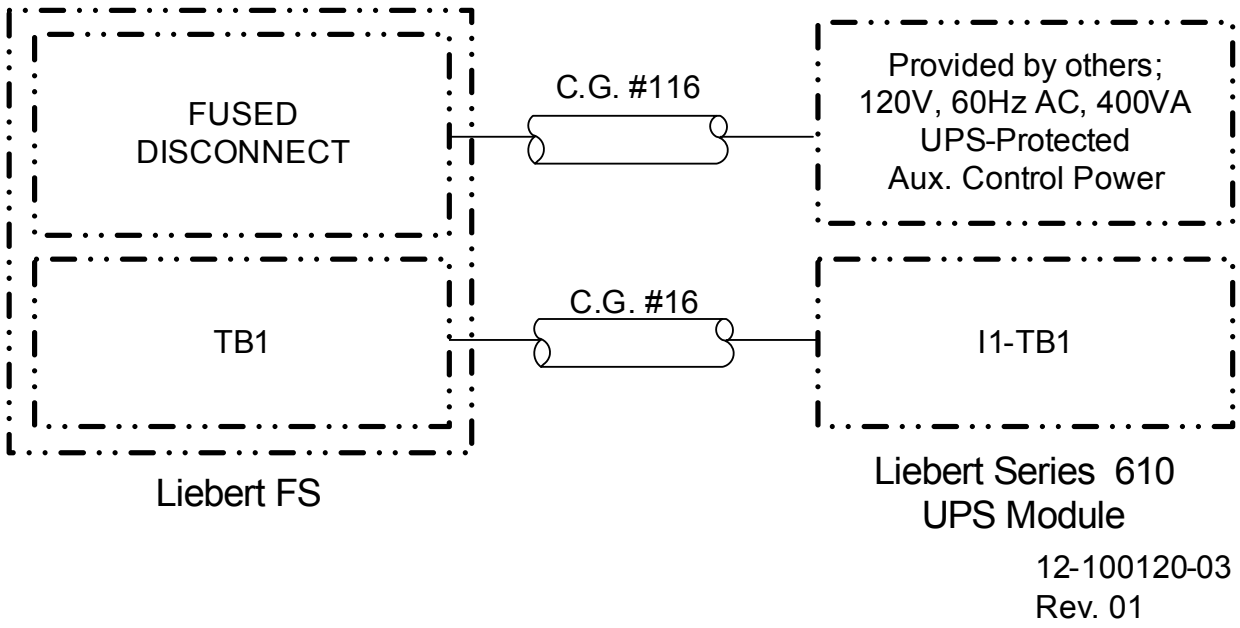


Figure 128 Control wiring—external interconnect diagram, Liebert FS cabinet to Liebert Series 610 UPS module



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Rev. 01

Figure 129 Control wiring—external interconnect diagram, Liebert FS cabinet to Liebert Series 610 UPS module

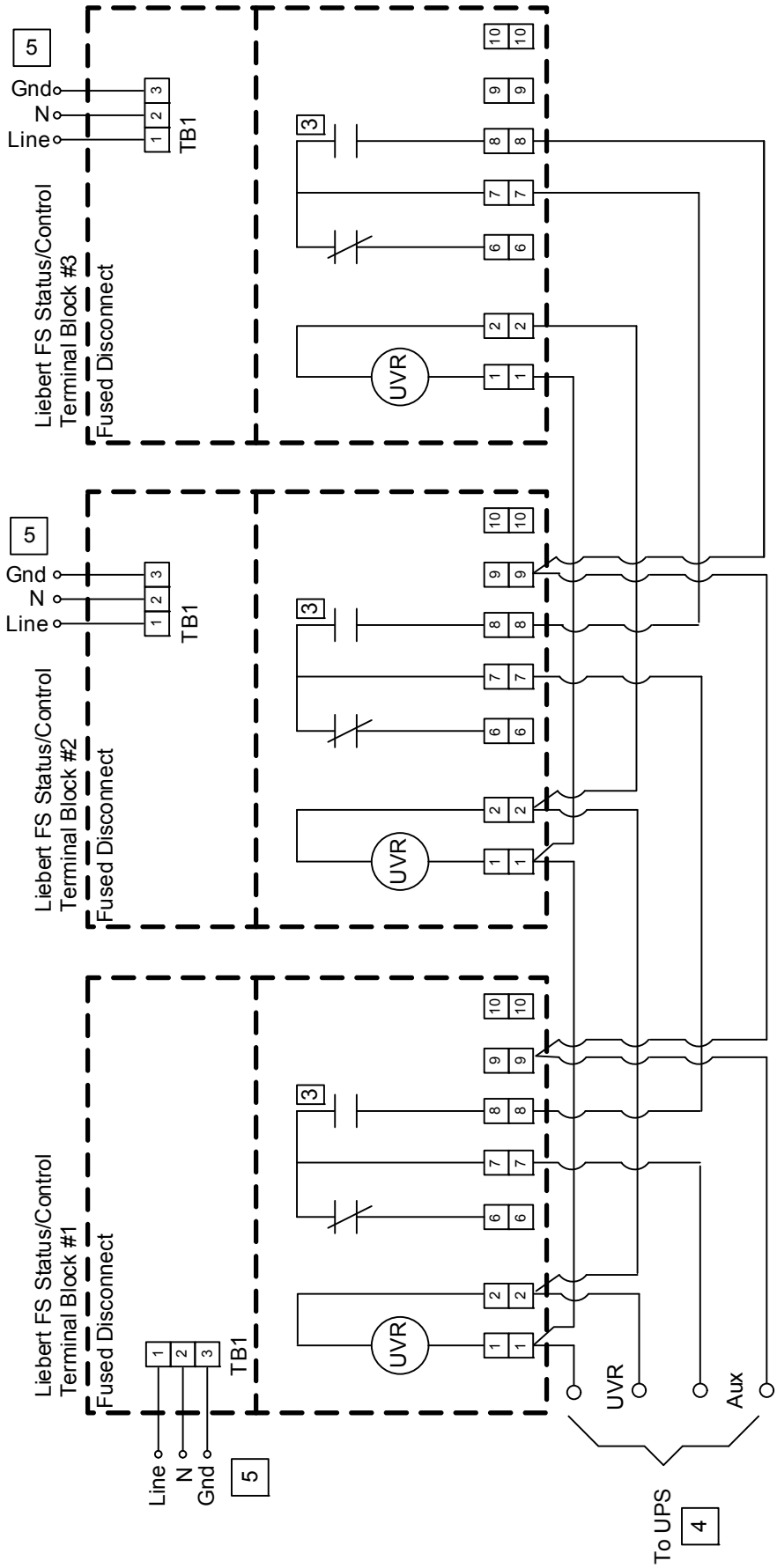

Figure 130 Elevation drawing, Liebert FS cabinet with shipping package

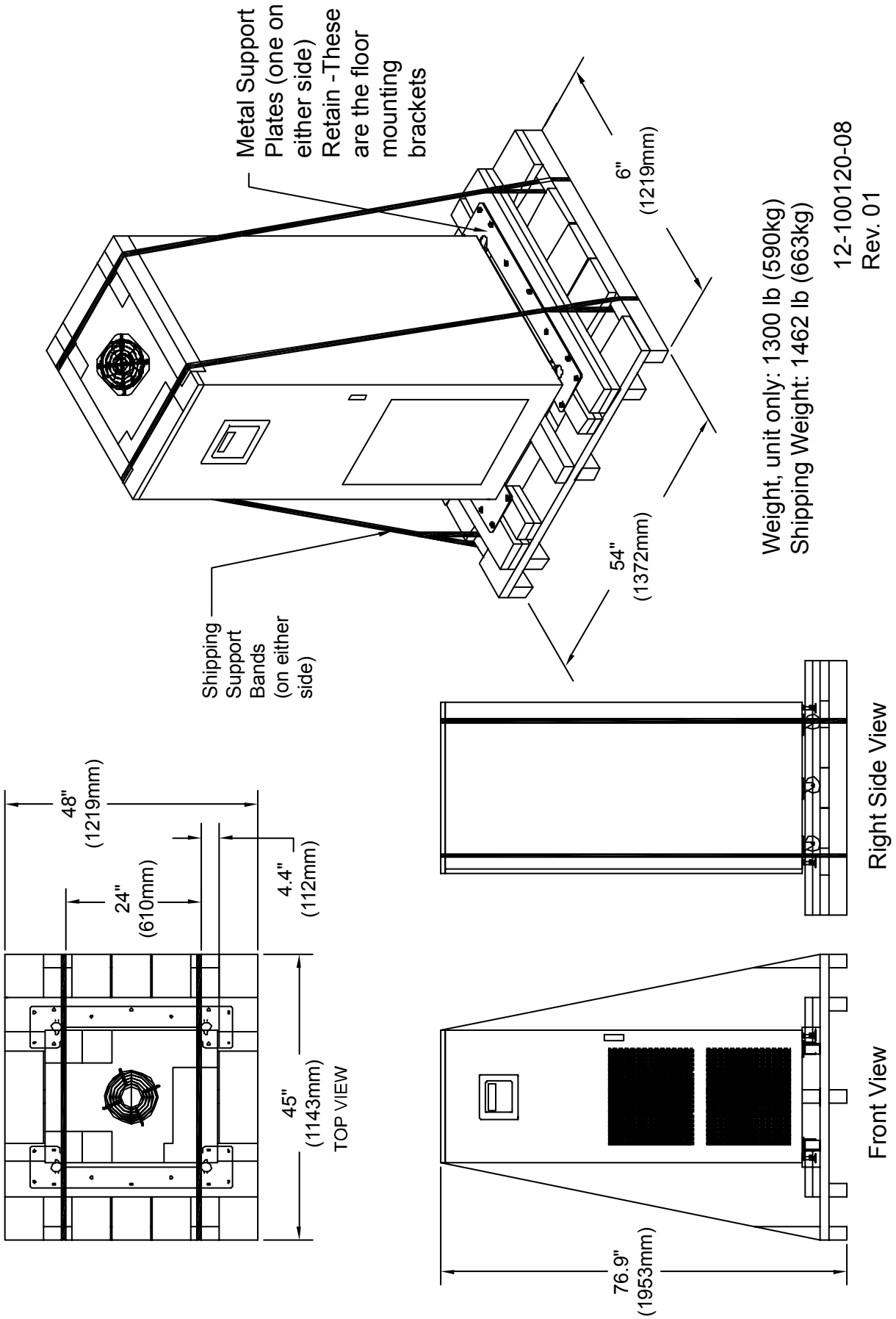

Figure 131 Elevation drawing—Liebert FS cabinet

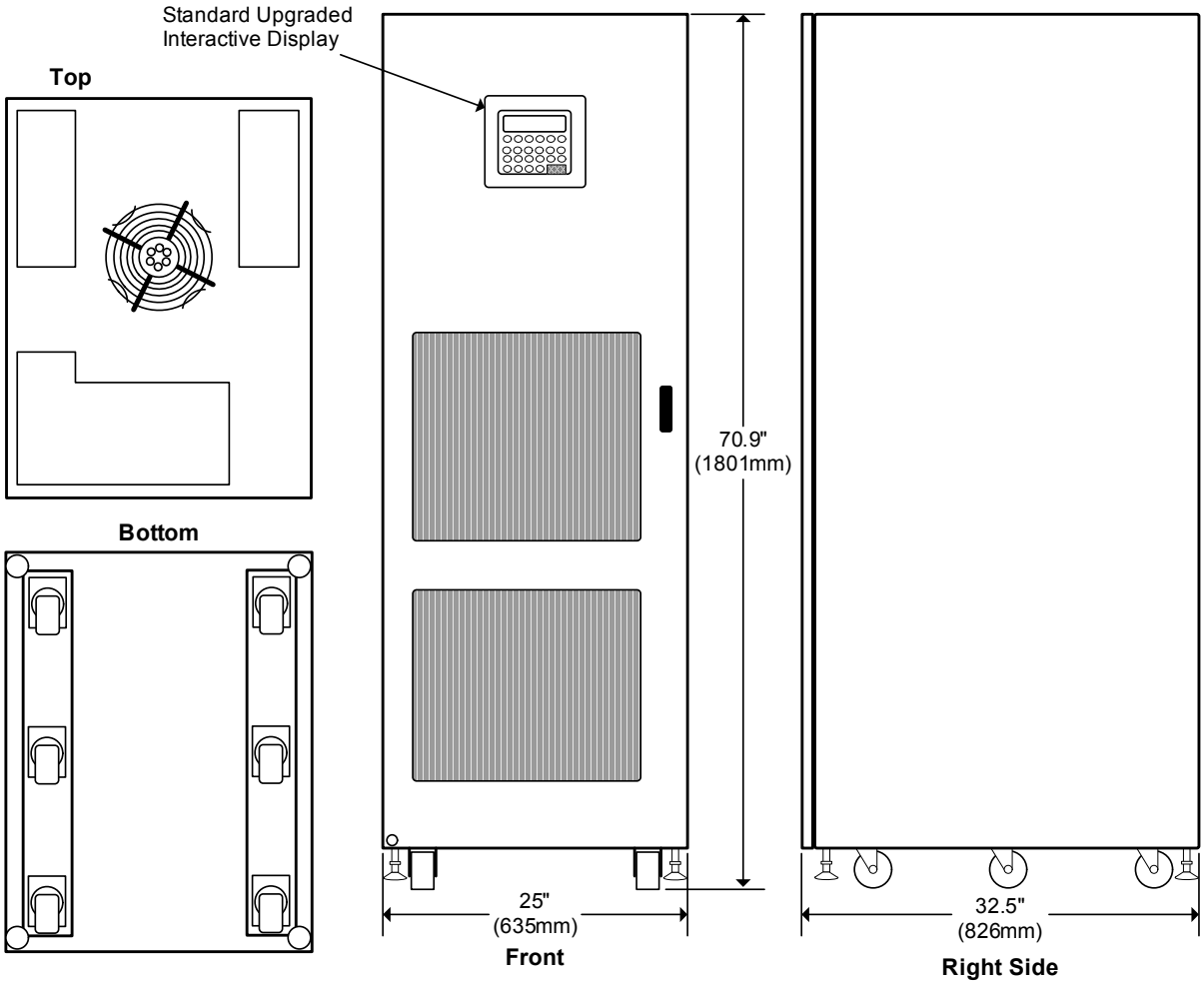

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Figure 132Control wiring diagram, Liebert FS power rack system in parallel for capacity

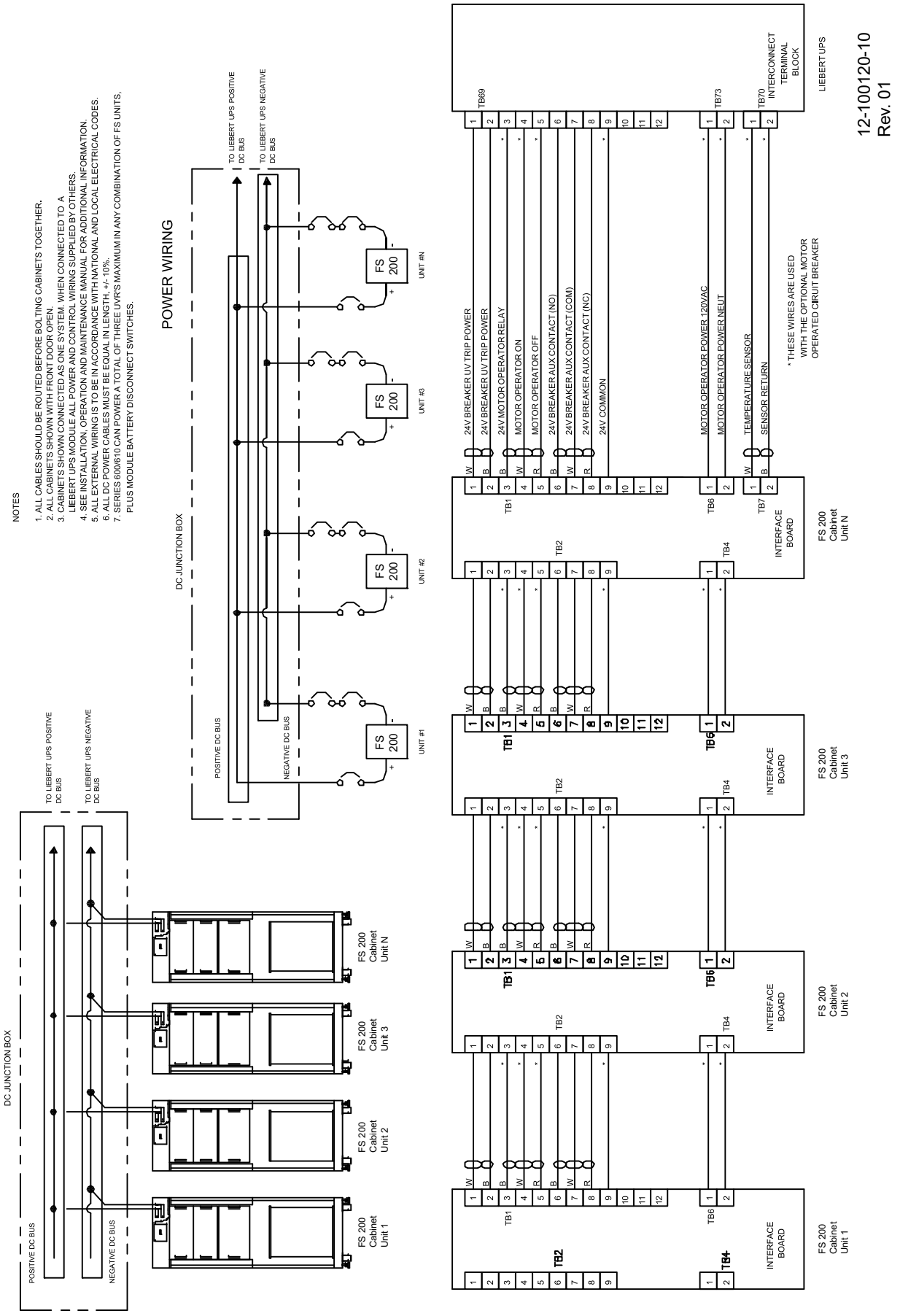


Figure 133Liebert FS cabinet with optional power terminal block

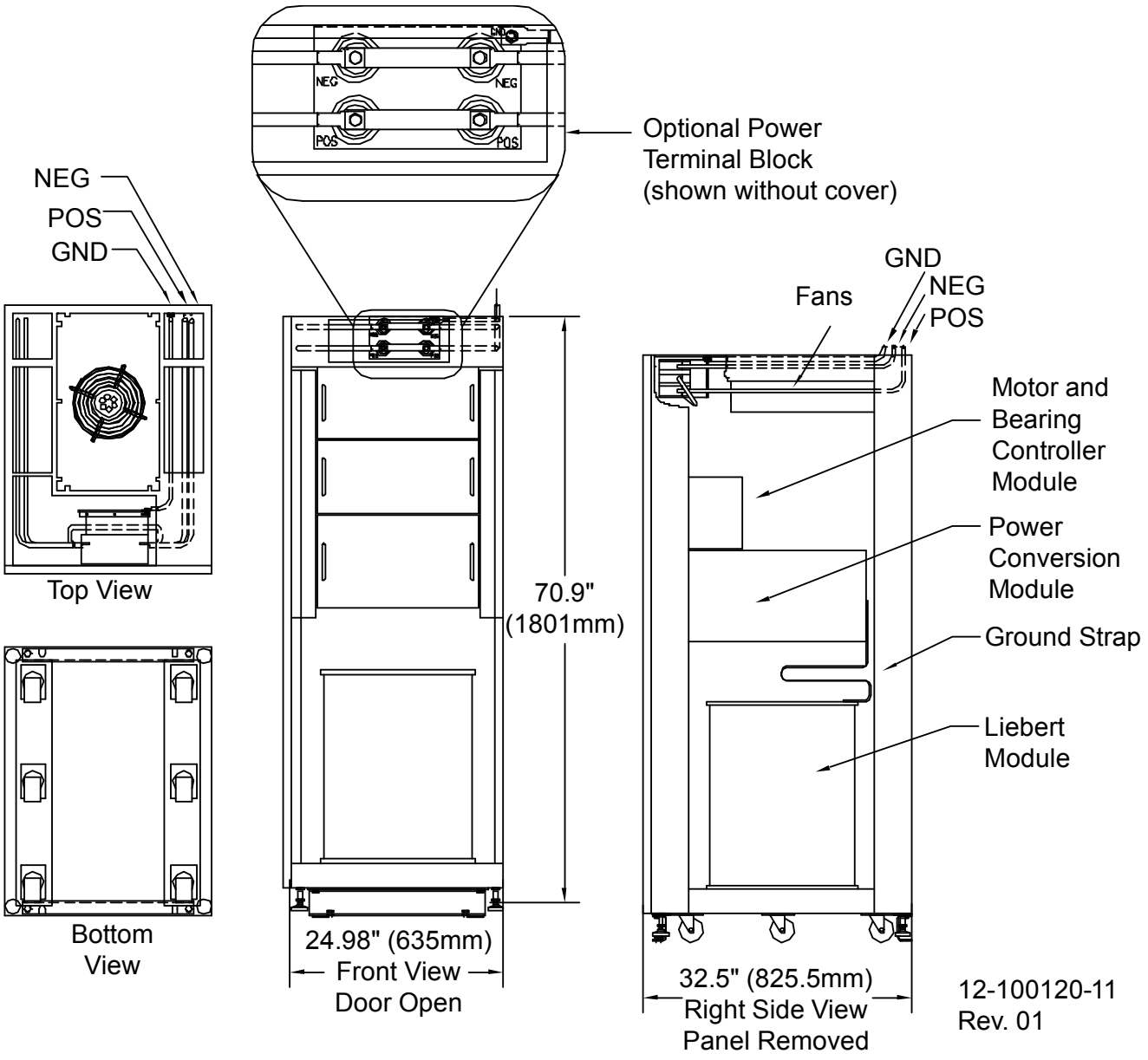


Figure 134Liebert FS cabinet mechanical installation

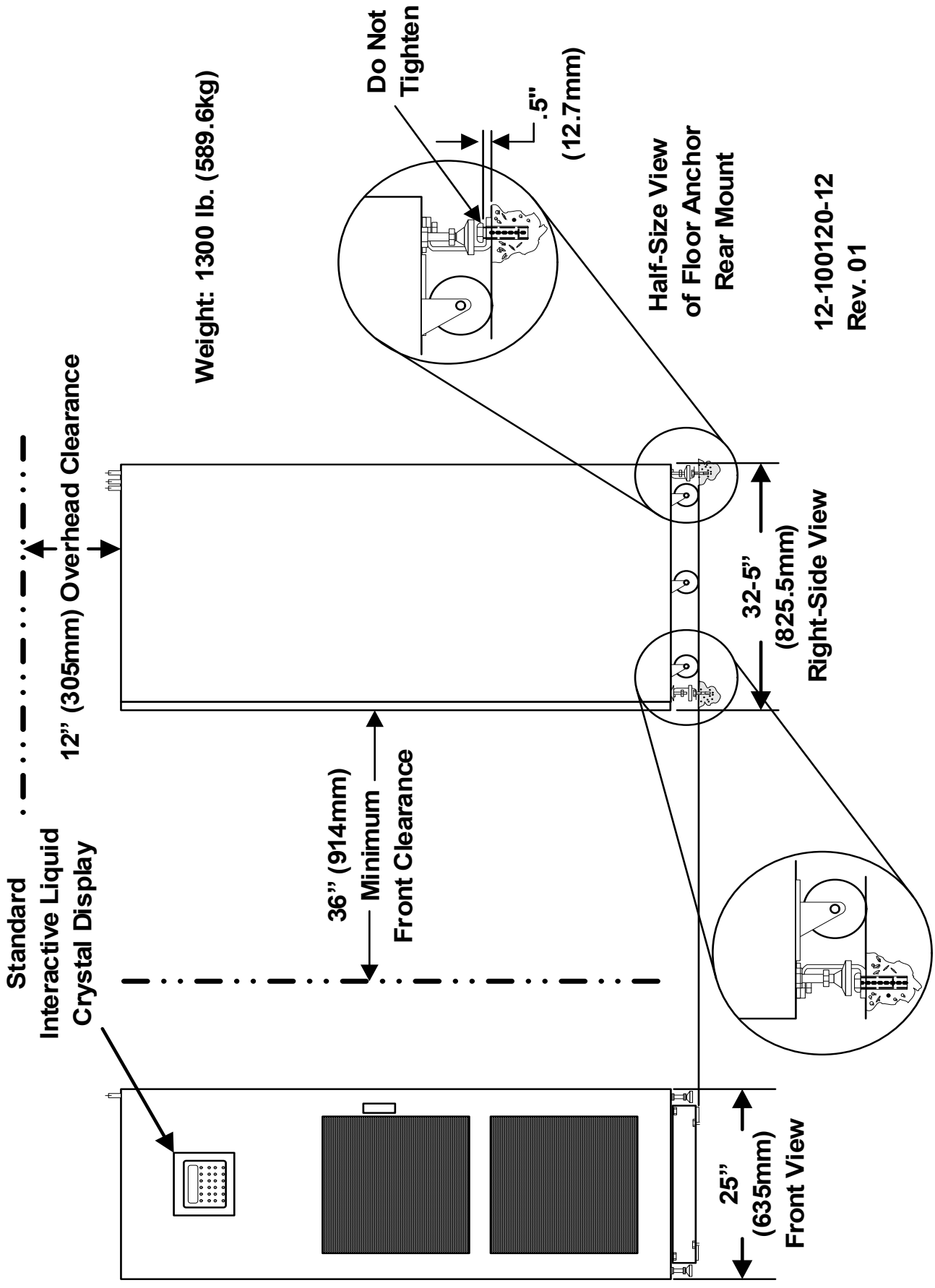


Figure 135Elevation drawing—Liebert FS cabinet with integrated circuit breaker

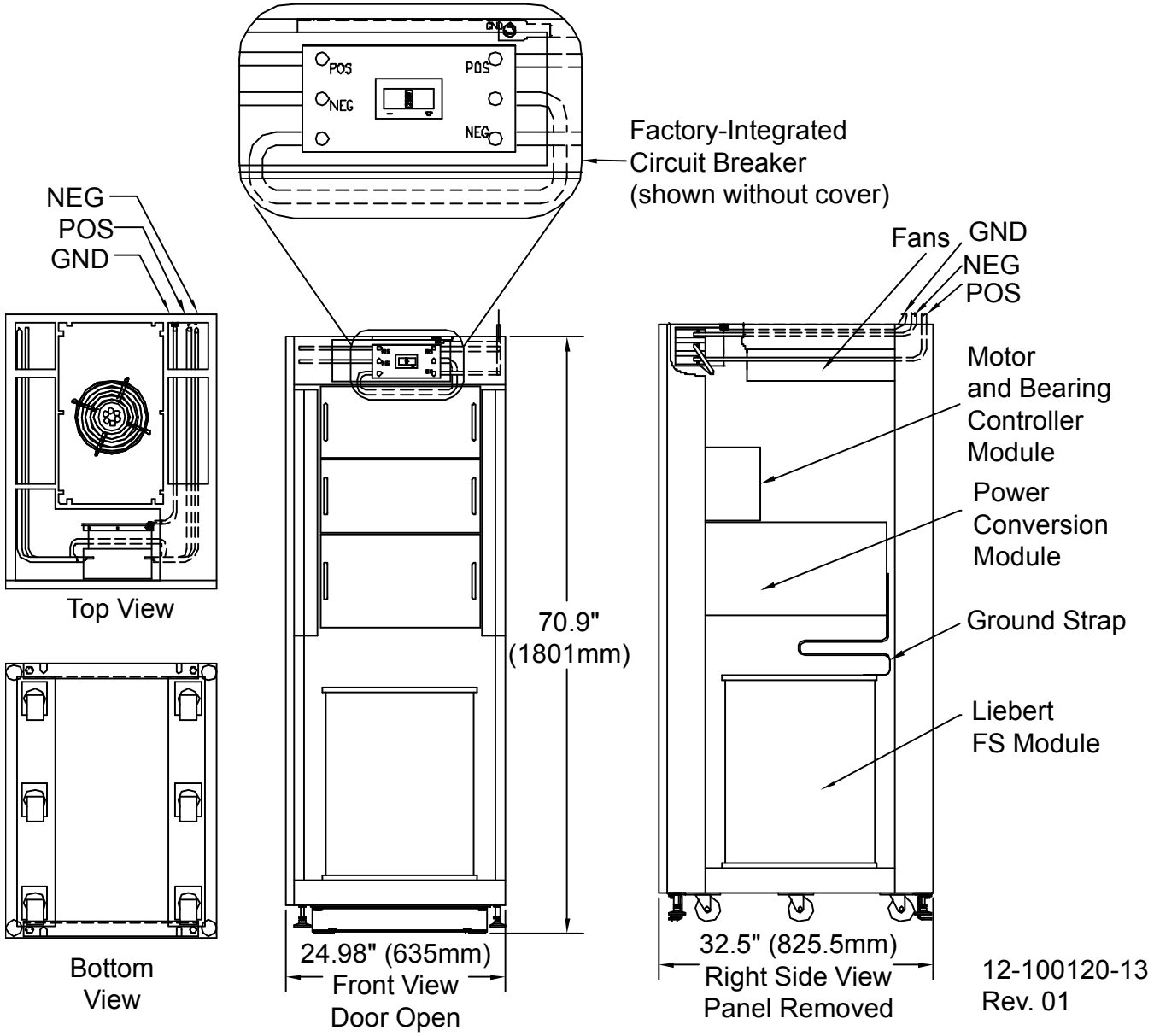


Figure 136One-line drawing, three Liebert FS systems in parallel configuration

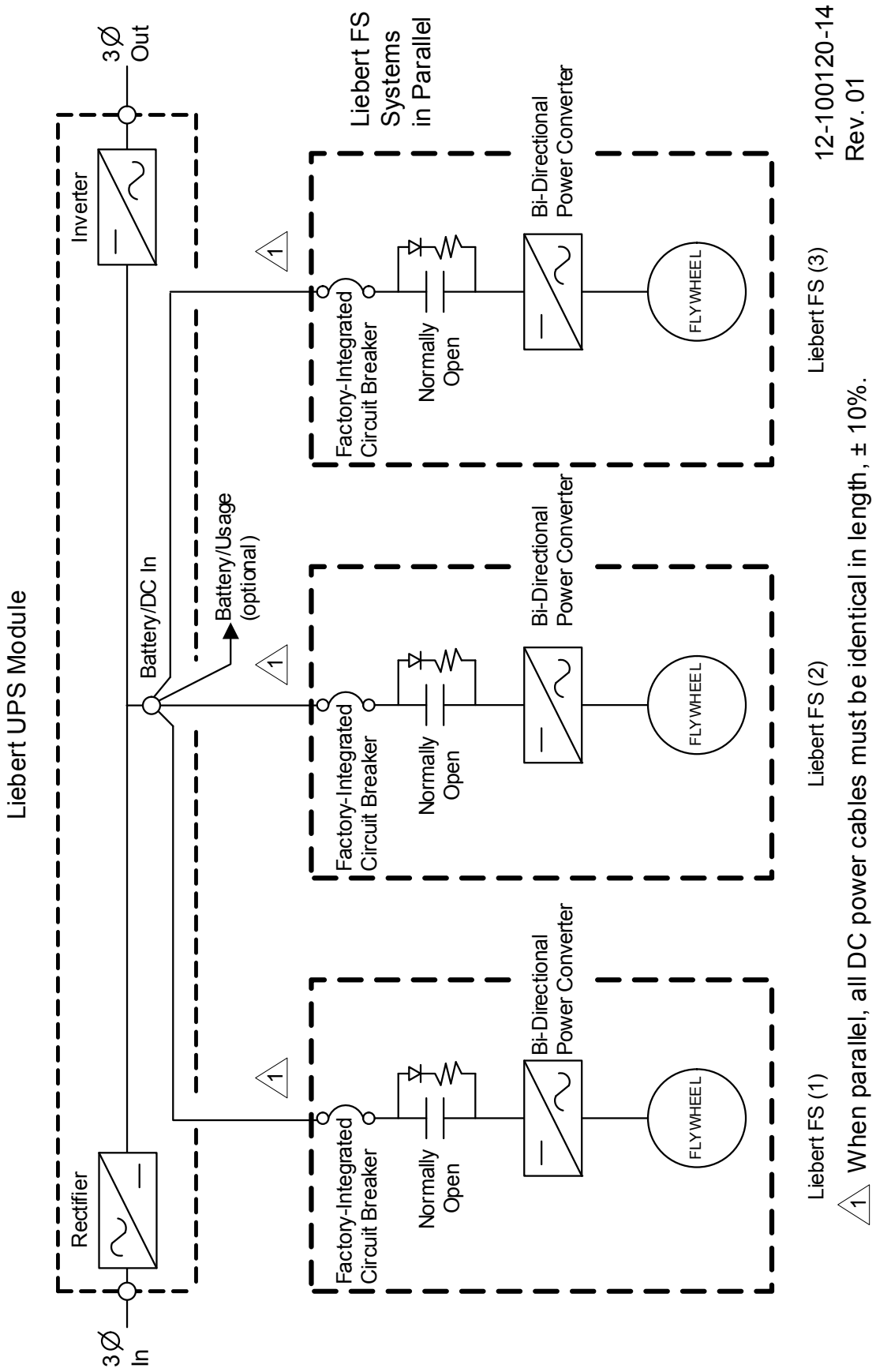


Figure 137 Control wiring diagram—Liebert FS cabinet - manually operated circuit breaker

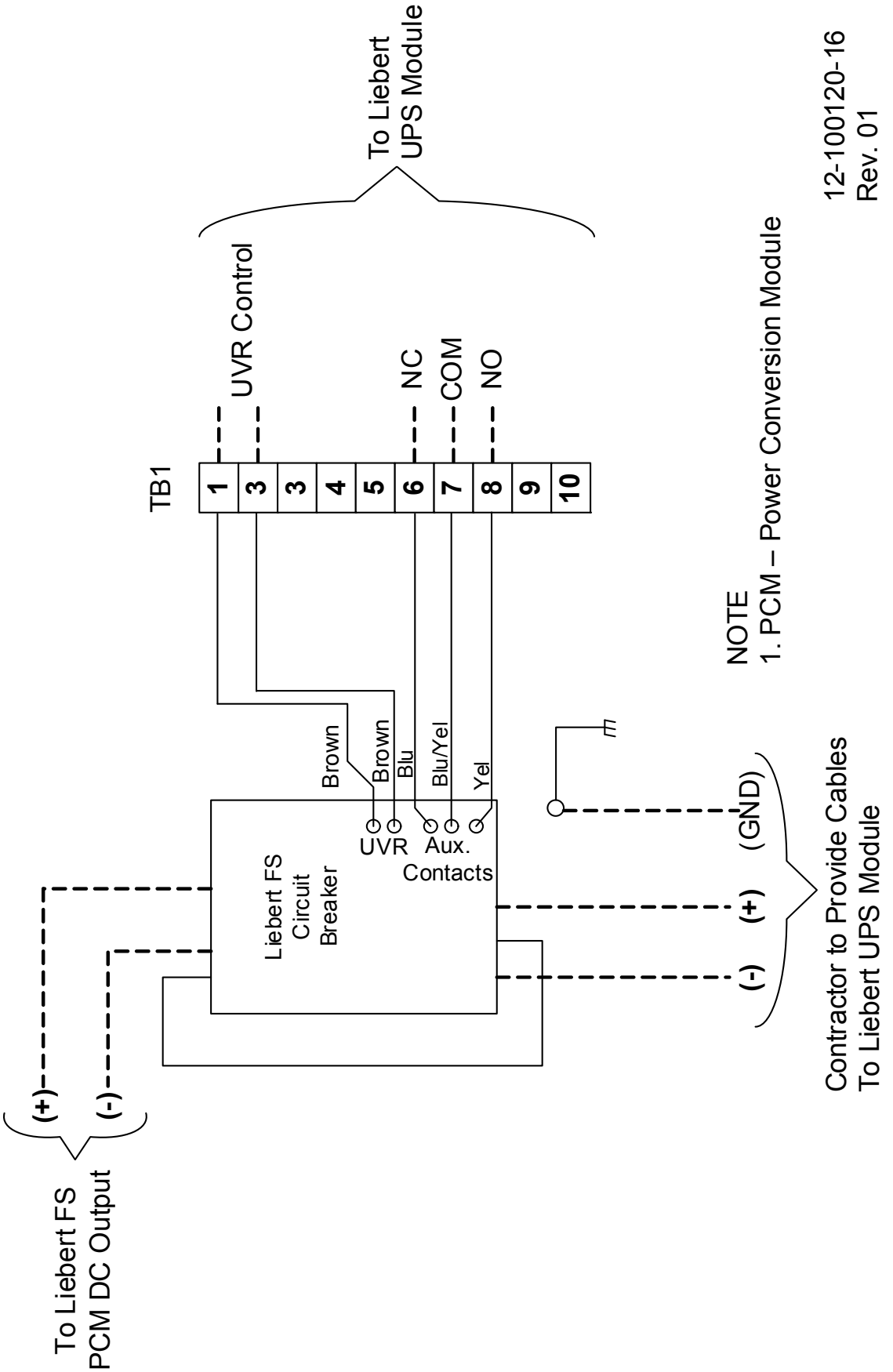


Figure 138 One-line diagram—Liebert FS systems with factory-integrated circuit breakers with Liebert UPS module

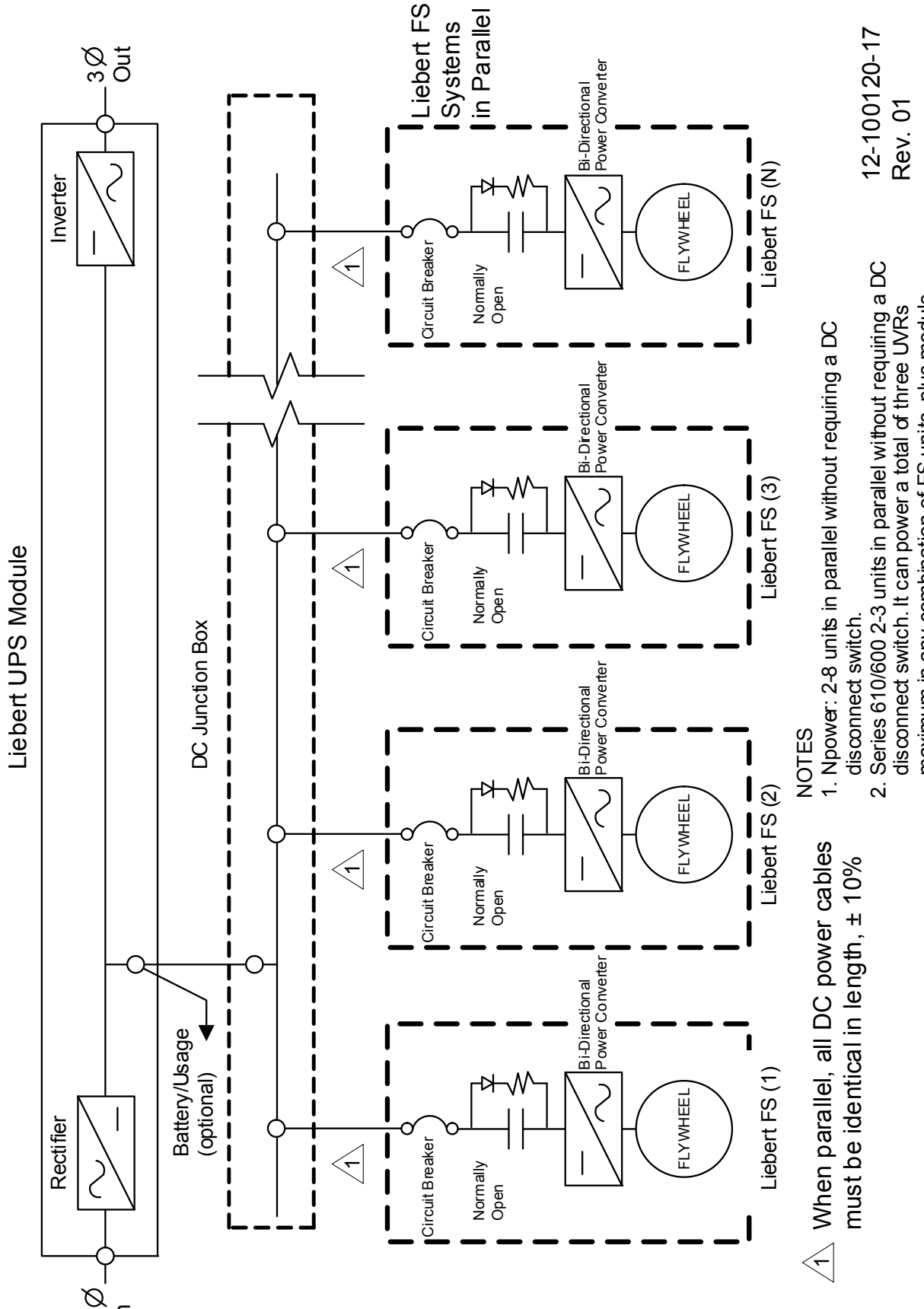


Figure 139 One-line diagram—single Liebert FS system with factory-integrated circuit breaker supplying Liebert UPS module

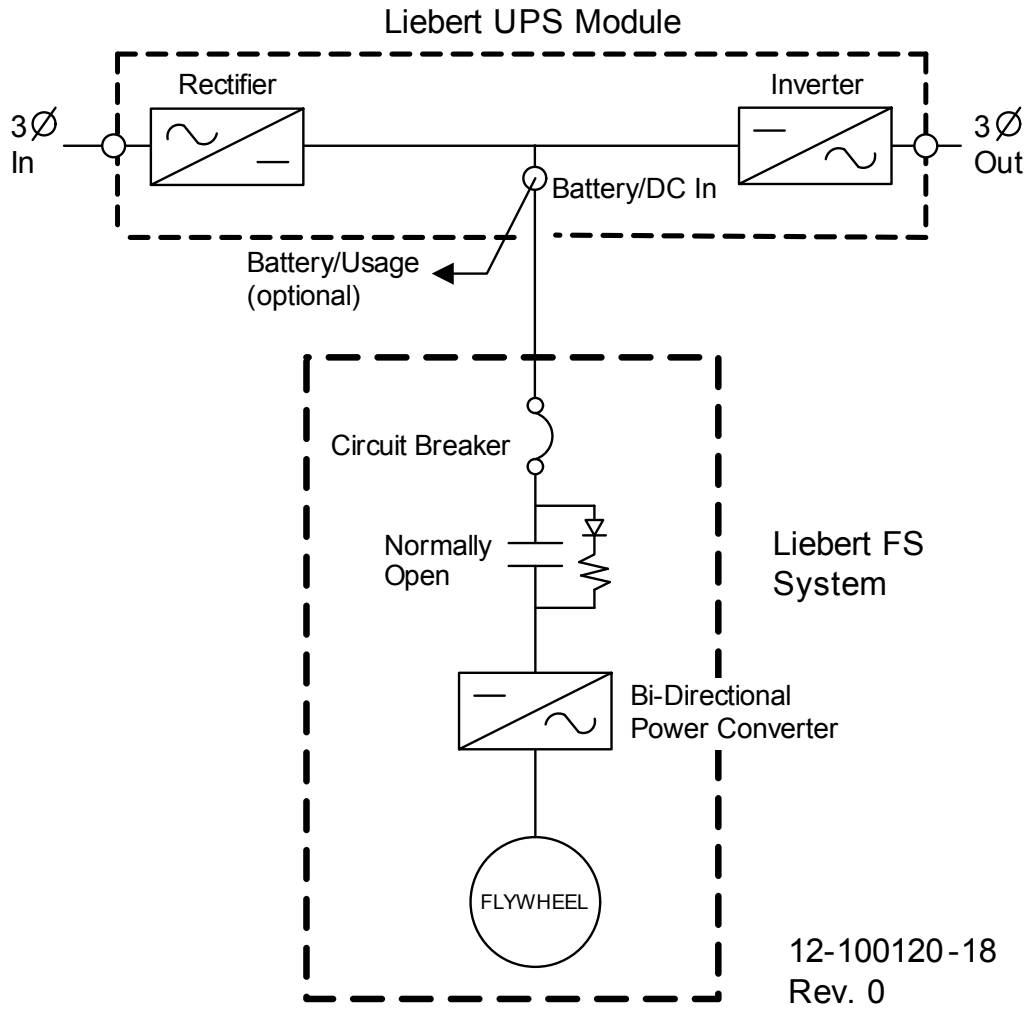


Figure 140 Control wiring diagram—Liebert FS - optional electrically operated circuit breaker Liebert Npower units

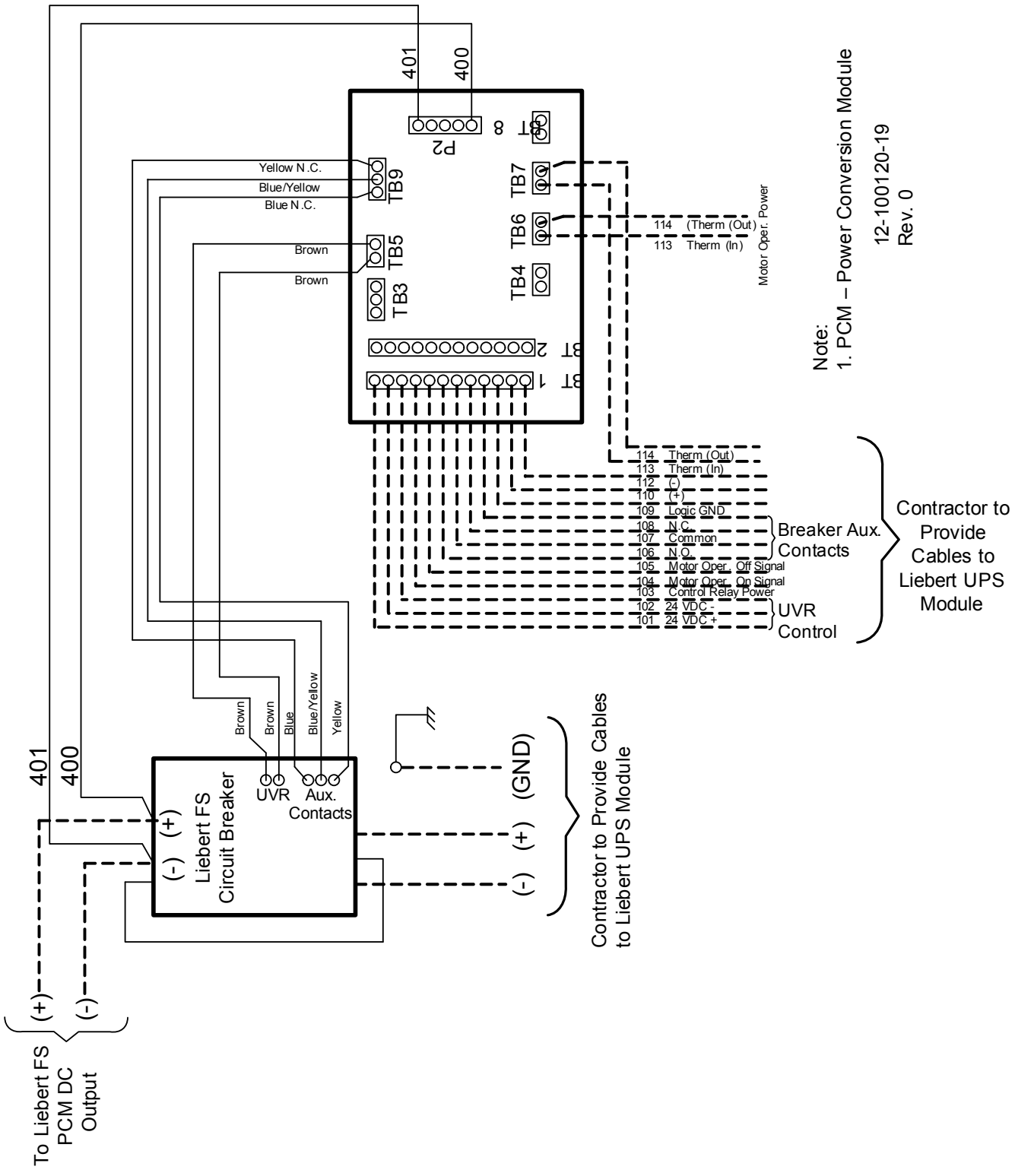


Figure 141 Two-eight paralleled Liebert FS units with factory-integrated circuit breaker in parallel with a Liebert UPS

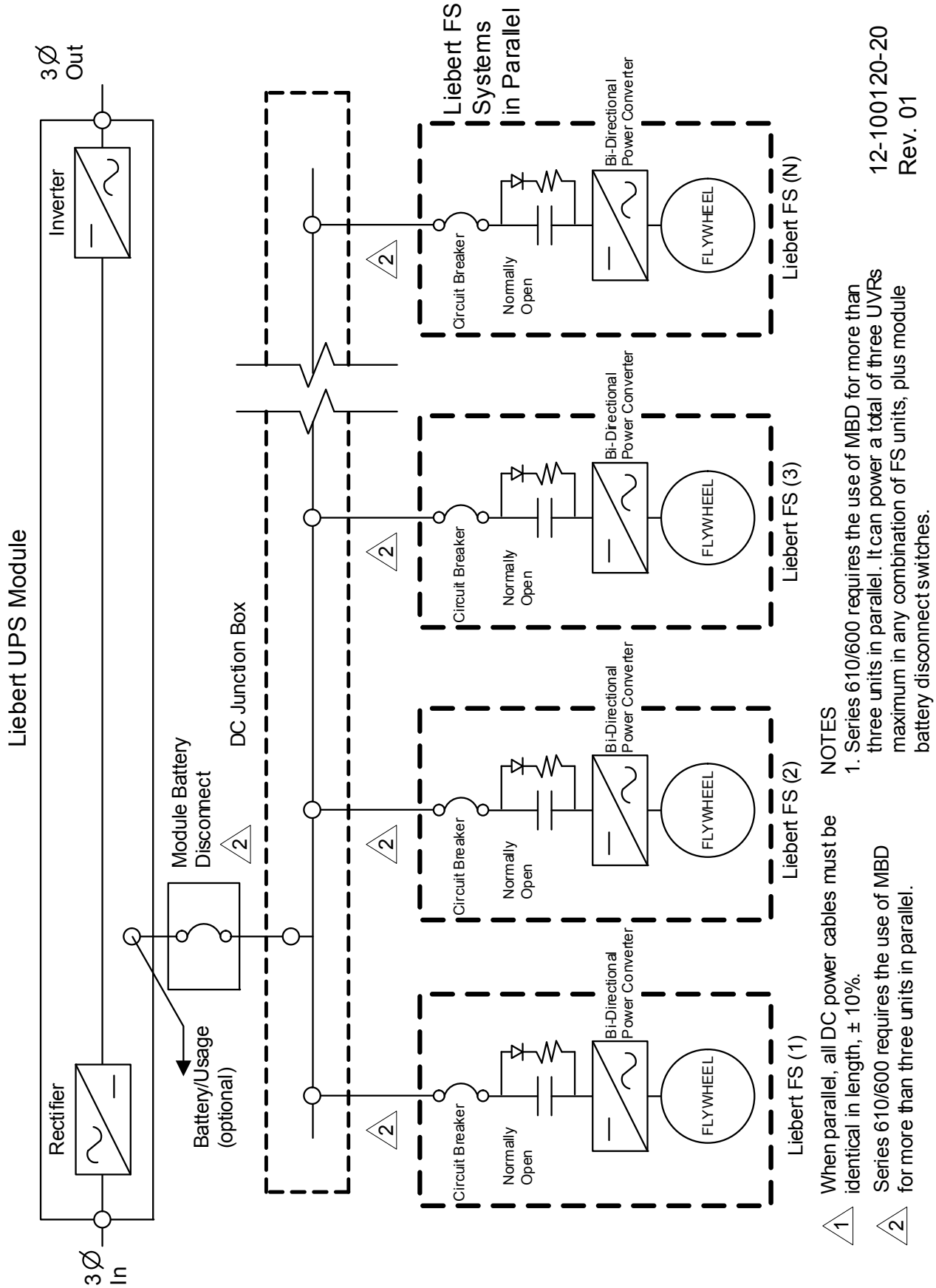


Figure 142 One-line diagram, single Liebert FS and battery with factory-integrated circuit breaker supplying Liebert UPS—UPS DC terminal point of common connection

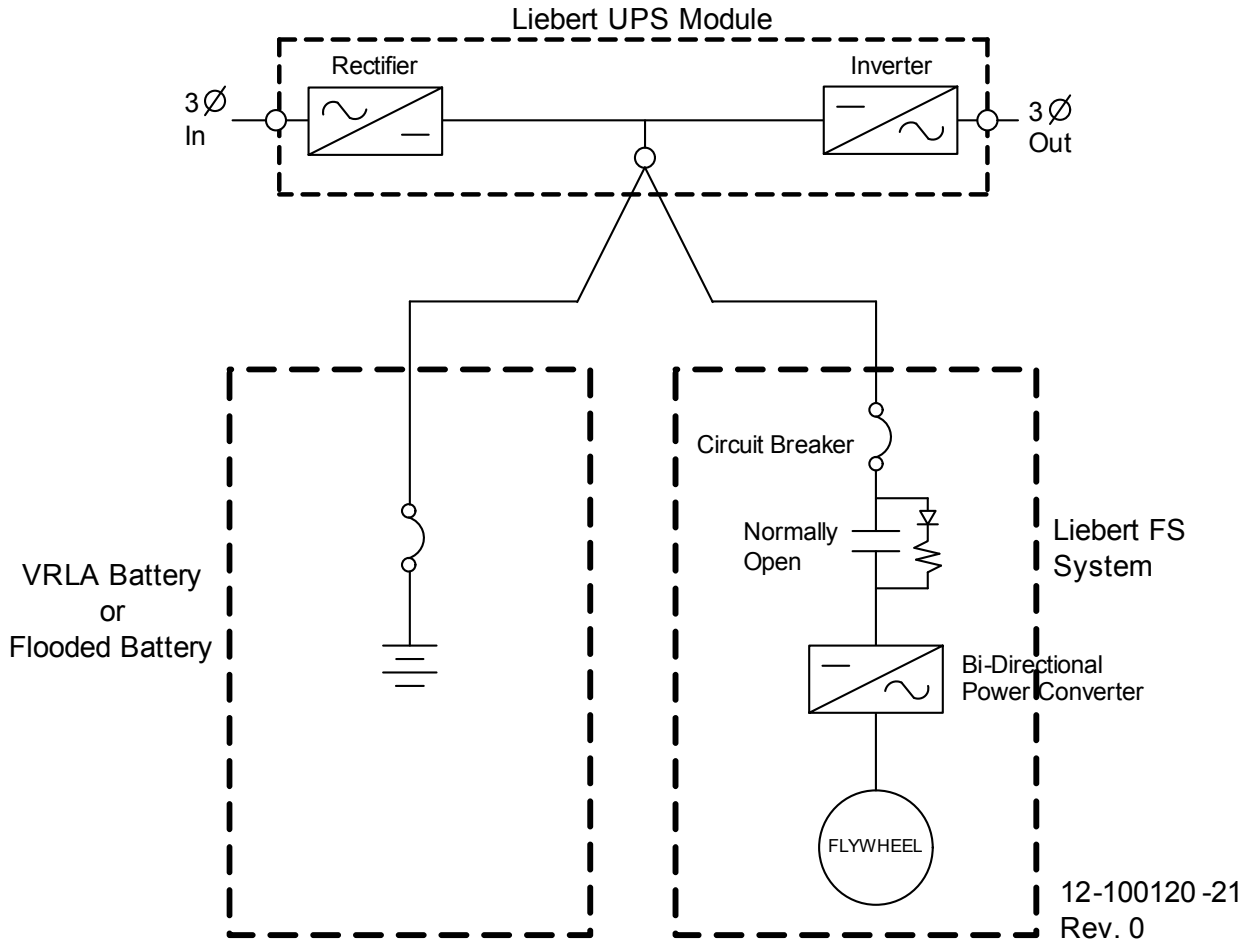


Figure 143 One-line diagram, single Liebert FS and battery with factory-integrated circuit breaker supplying Liebert UPS—UPS battery point of common connection

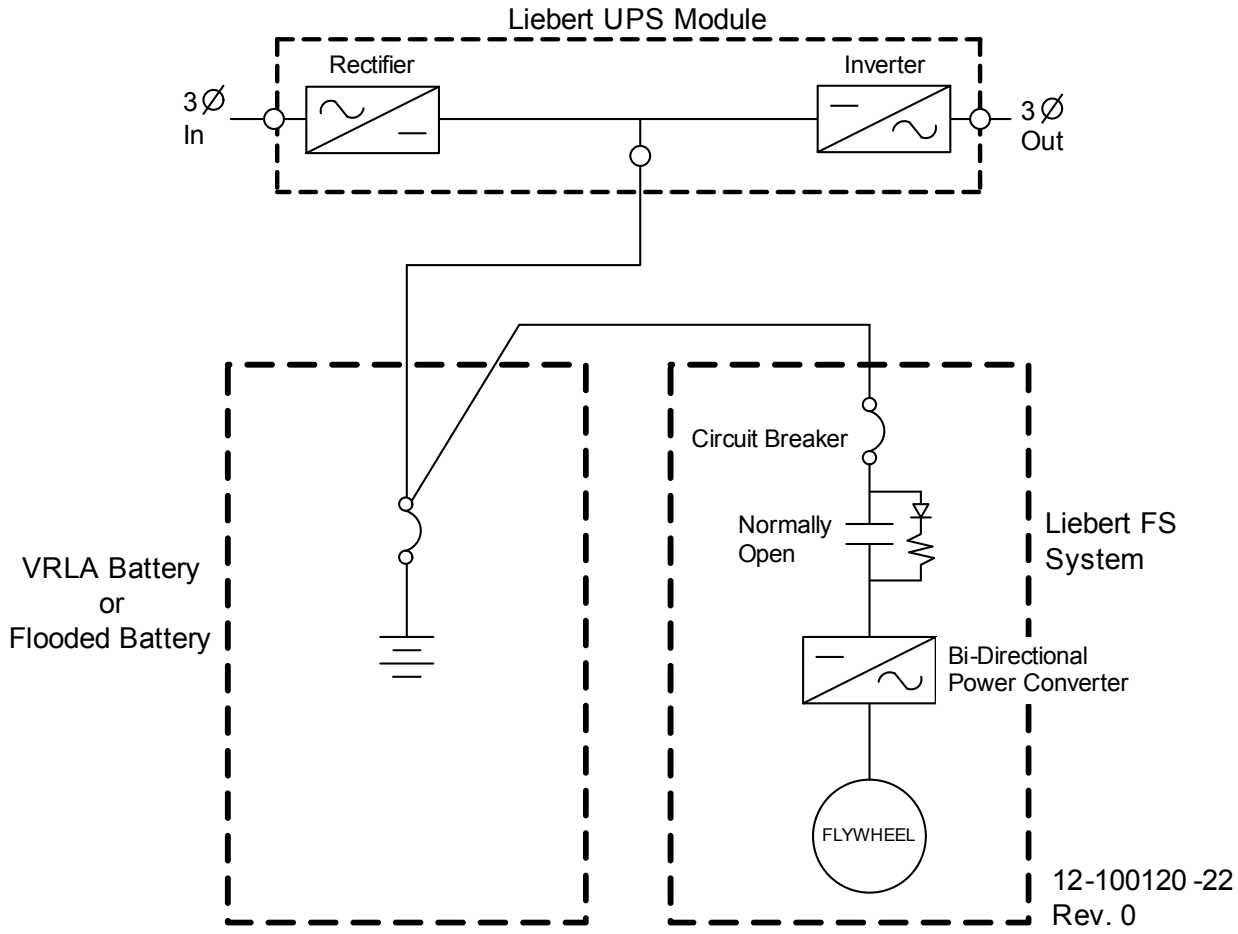
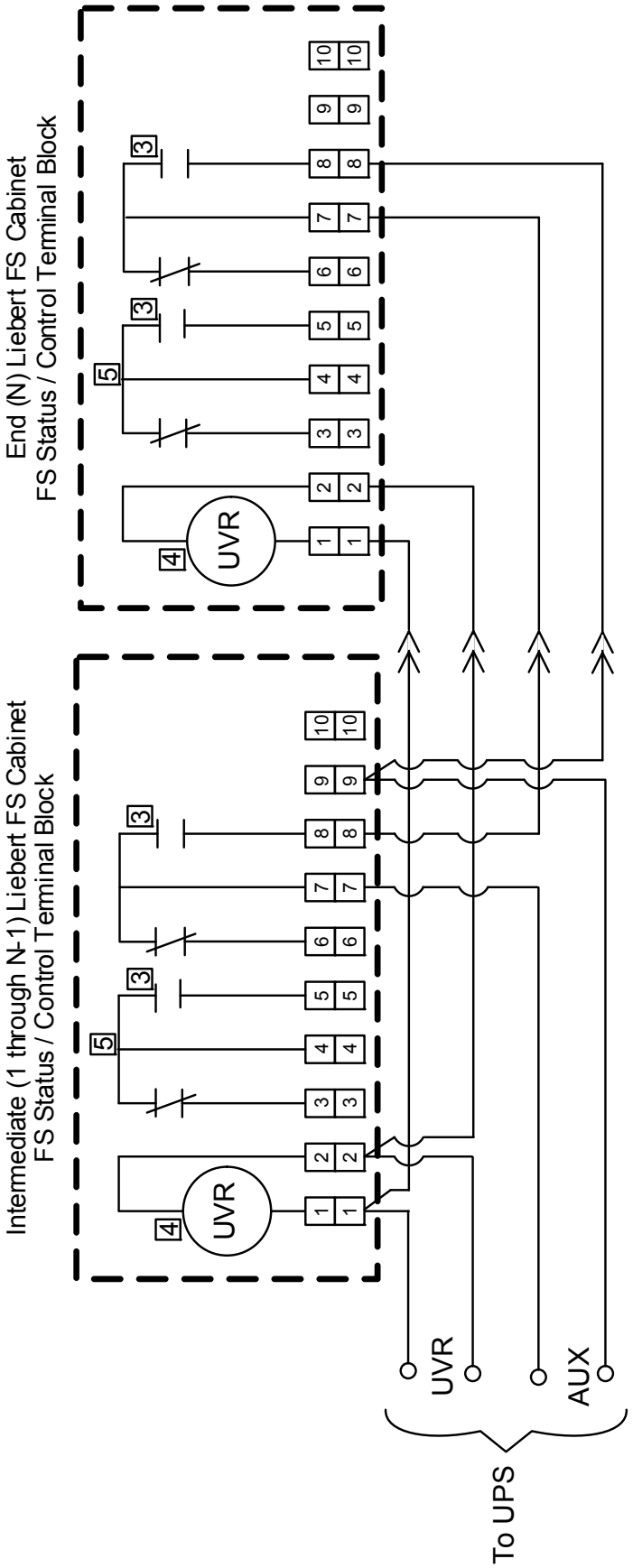


Figure 144 Status/control wiring, multiple units



Notes: Unless Otherwise Specified

1. Minimum UV coil current must be N times 50mA where N = Number of Liebert FS paralleled units.
2. 16 AWG-600VDC (minimum) wires to be provided and installed by customer or installation contractor.

[3.] Contact closed when circuit breaker is closed

[4.] UVR not available with IKIT-CB1, A05, D01, E01.

[5.] Available only with IKIT-CB1, A05, D01, E01.

Figure 145 Wiring specifications, Liebert FS and Liebert Series 300

Wire No.	Terminal Designation		Signal Name	Maximum Voltage	Maximum Current	Color	Wire Size & Type	Maximum Length	Remarks
	From	To							
Series 300 UPS - Cable Group # 27 (Flywheel CB IFM) From I1 In UPS Module to TB1 on Liebert FS Module									
901	I1-TB1-1	TB1-1	Trip Signal (+)	+24 VDC	100mA		1/C #16 (2.5 mm^2) Stranded	500 ft (150 m)	
902	I1-TB1-2	TB1-2	Trip Signal (-)	-24 VDC	100mA				
903	I1-TB1-7	TB1-7	Aux Comm	24 VDC	100mA				
904	I1-TB1-8	TB1-8	Aux N.O.	24 VDC	100mA				
Series 300 UPS - Cable Group # 116 Flywheel Aux Power, Customer-Provided to Liebert FS TB1 on Fused Disconnect									
914	FBO	TB1-1	Line	120VAC	3.5A		1/C #16 (2.5 mm^2) Stranded	500 Ft (150 Meters)	UPS-Protected Auxiliary Control Power
915	FBO	TB1-2	Neutral	120VAC	3.5A				
916	FBO	TB1-3	GND	120VAC	3.5A				

1. Each cable group must be run in a separate, grounded, rigid metal conduit to prevent control signal interference.
2. Refer to UPS module/Liebert FS control connection diagram for location of wiring connections.
3. All external wires furnished by others.
4. N.O. = Normally Open; N.C. = Normally Closed; Comm = Common; F.B.O. = Furnished By Others, GND = Ground
5. All wiring must be in accordance with national and local electrical codes.

Dwg. No. Control_WL_S300_Liebert-FS Rev. 01

Figure 146 Wiring specifications, Liebert FS and Liebert Npower

Wire No.	Terminal Designation		Signal Name	Maximum Voltage	Maximum Current	Color	Wire Size & Type	Maximum Length	Remarks
	From	To							
Liebert N-Power UPS - Cable Group # 17 (Flywheel CB IFM) From TB69 in UPS Module to TB1 on Liebert FS Module									
101	TB69-1	TB1-1	Trip Signal (+)	+24 VDC	100mA		1/C #16 (2.5 mm^2) Stranded	500 ft (150m)	
102	TB69-2	TB1-2	Trip Signal (-)	-24 VDC	100mA				
103	TB69-3	TB1-3	Motor Op Relay	24 VDC	100mA				
104	TB69-4	TB1-4	Motor Op On	24 VDC	100mA				
105	TB69-5	TB1-5	Motor Op Off	24 VDC	100mA		1/C #16 (2.5 mm^2) Stranded		
106	TB69-6	TB1-6	Aux N.O.	24 VDC	100mA				
107	TB69-7	TB1-7	Aux Comm	24 VDC	100mA				
108	TB69-8	TB1-8	Aux N.C.	24 VDC	100mA				
109	TB69-9	TB1-9	Comm	24 VDC	100mA				
110	TB69-10	TB1-10	Battery Sense (+)	+24 VDC	100mA				
112	TB69-12	TB1-11	Battery Sense (-)	-24 VDC	100mA				
Liebert N-Power UPS - Cable Group # 18 (Flywheel CB IFM) from TB73 in UPS Module to TB6 on Liebert FS Module									
Line	TB73-1	TB6-1	Motor Op Pwr	120 VAC	100mA			500 FT (150m)	
Neutral	TB73-2	TB6-2	Motor Op Neutral	N	100mA				
Liebert N-Power UPS - Cable Group # 19 (Flywheel CB IFM) From TB70 in UPS Module to TB7 on Liebert FS Module									
113	TB70-1	TB7-1	Temp Sensor	24 VDC	100mA		1/C #16 (2.5 mm^2) Stranded	500 ft (150m)	
114	TB70-2	TB7-2	Sensor Return	24 VDC	100mA				
Liebert N-Power UPS - Cable Group # 116 Flywheel Aux Power, Customer Provided to Liebert FS TB1 on Fused Disconnect									
Output A PHS	FBO	TB1-1	Line	120VAC	3.5A		1/C #16 (2.5 mm^2) Stranded	500 ft (150m)	UPS-Protected Auxiliary Control Power
Output Net	FBO	TB1-2	Neutral	120VAC	3.5A				
Gnd	FBO	TB1-3	GND	120VAC	3.5A				

1. Each cable group must be run in a separate grounded rigid metal conduit to prevent control signal interference.
2. Refer to UPS module/Liebert FS control connection diagram for location of wiring connections.
3. All external wires furnished by others.
4. N.O. = Normally Open; N.C. = Normally Closed; Comm = common; F.B.O. = Furnished By Others, GND = ground
5. All wiring must be in accordance with national and local electrical codes.

Dwg. No. Control_WL_NPower_Liebert-FS Rev. 1

Figure 147 Wiring specifications, Liebert FS and Liebert Series 610

Wire No.	Terminal Designation		Signal Name	Maximum Voltage	Maximum Current	Color	Wire Size & Type	Maximum Length	Remarks
	From	To							
Liebert Series 610 UPS - Cable Group #16 (Flywheel CB IFM) From I1 in UPS Module to TB1 on Liebert FS Module									
901	I1-TB1-1	TB1-1	Trip Signal (+)	+24 VDC	100mA		1/C #16 (2.5 mm^2) Stranded	500 Ft (150 M	
902	I1-TB1-2	TB1-2	Trip Signal (-)	-24 VDC	100mA				
903	I1-TB1-7	TB1-7	Aux Comm	24 VDC	100mA				
904	I1-TB1-8	TB1-8	Aux N.O.	24 VDC	100mA				
Liebert Series 610 UPS - Cable Group #116 Flywheel Aux Power, Customer-Provided to Liebert FS TB1 on Fused Disconnect									
914	FBO	TB1-1	Line	120VAC	3.5A		1/C #16 (2.5 mm^2) Stranded	500 Ft (150m)	UPS-Protected Auxiliary Power Control
915	FBO	TB1-2	Neutral	120VAC	3.5A				
916	FBO	TB1-3	GND	120VAC	3.5A				

1. Each cable group must be run in a separate, grounded, rigid metal conduit to prevent control signal interference.
2. Refer to UPS module/Liebert FS control connection diagram for location of wiring connections.
3. All external wires furnished by others.
4. N.O. = Normally Open; N.C. = Normally Closed; Comm = common; F.B.O. = Furnished By Others, GND = ground
5. All wiring must be in accordance with national and local electrical codes.

Dwg. No. Control_WL_S610_Liebert-FS Rev. 01

Figure 148 Wiring specifications, Liebert FS and Liebert HiPulse, Liebert NXL or Liebert NX

**WIRING SPECIFICATIONS FOR THE
LIEBERT FS AND LIEBERT HIPULSE, LIEBERT NXL OR LIEBERT NX
ARE AVAILABLE BY CONTACTING:**

Your local Liebert Sales Representative

Your local Liebert Service Representative

Liebert Corp. at 1-800-Liebert (1-800-543-2378

Figure 149 Floor mounting template

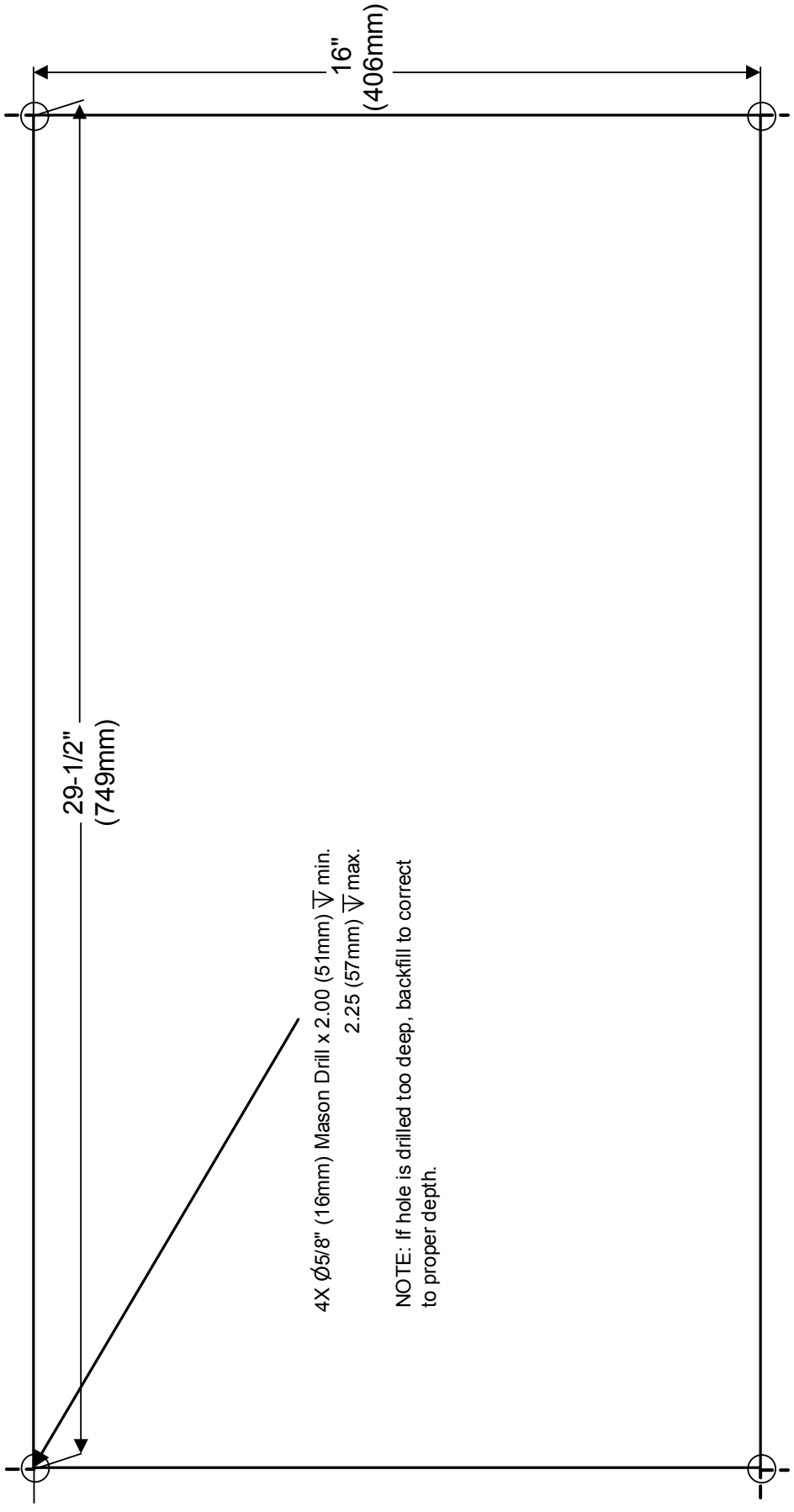


Figure 150 System mounting kit

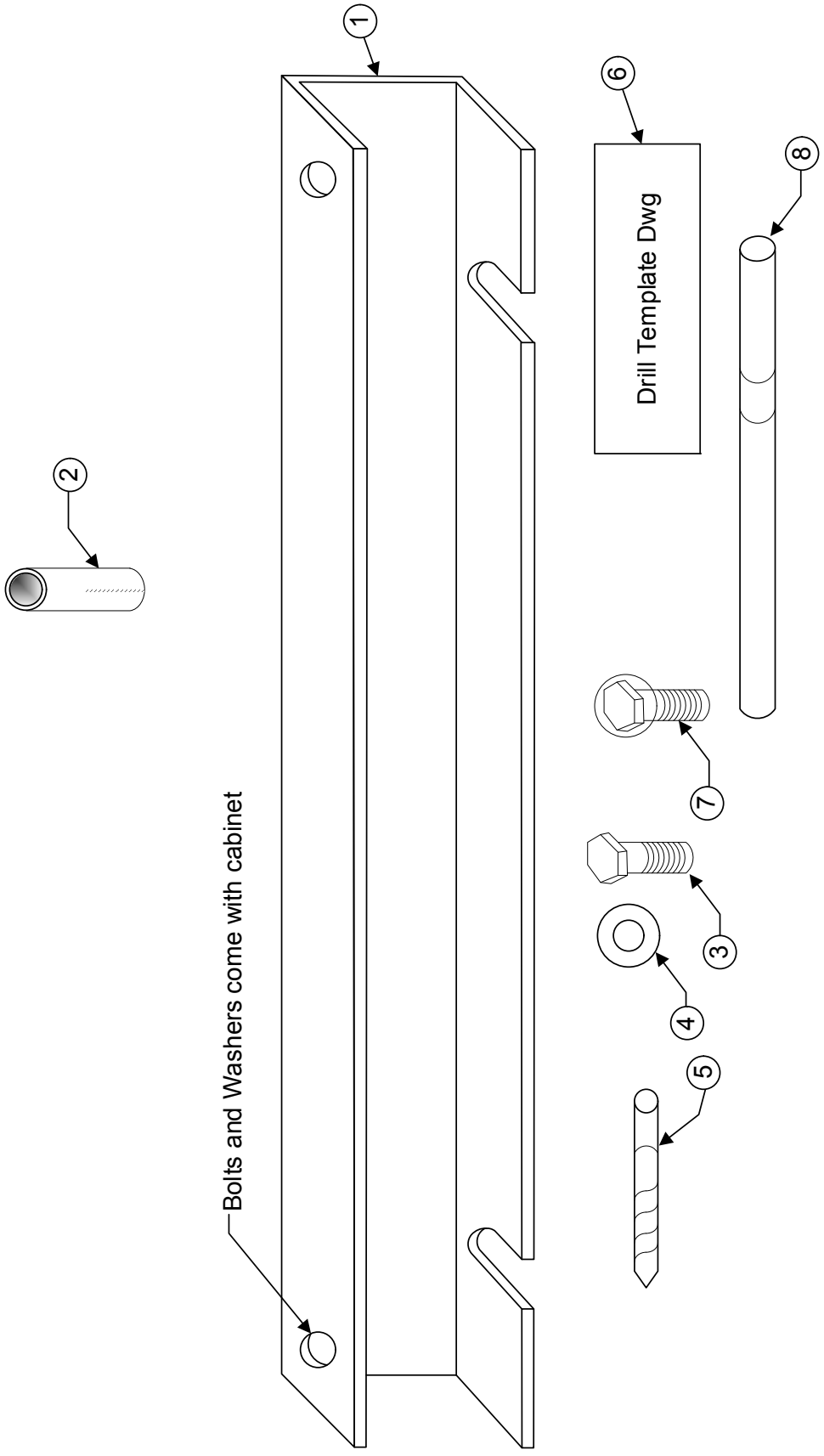


Figure 151 Liebert FS block diagram

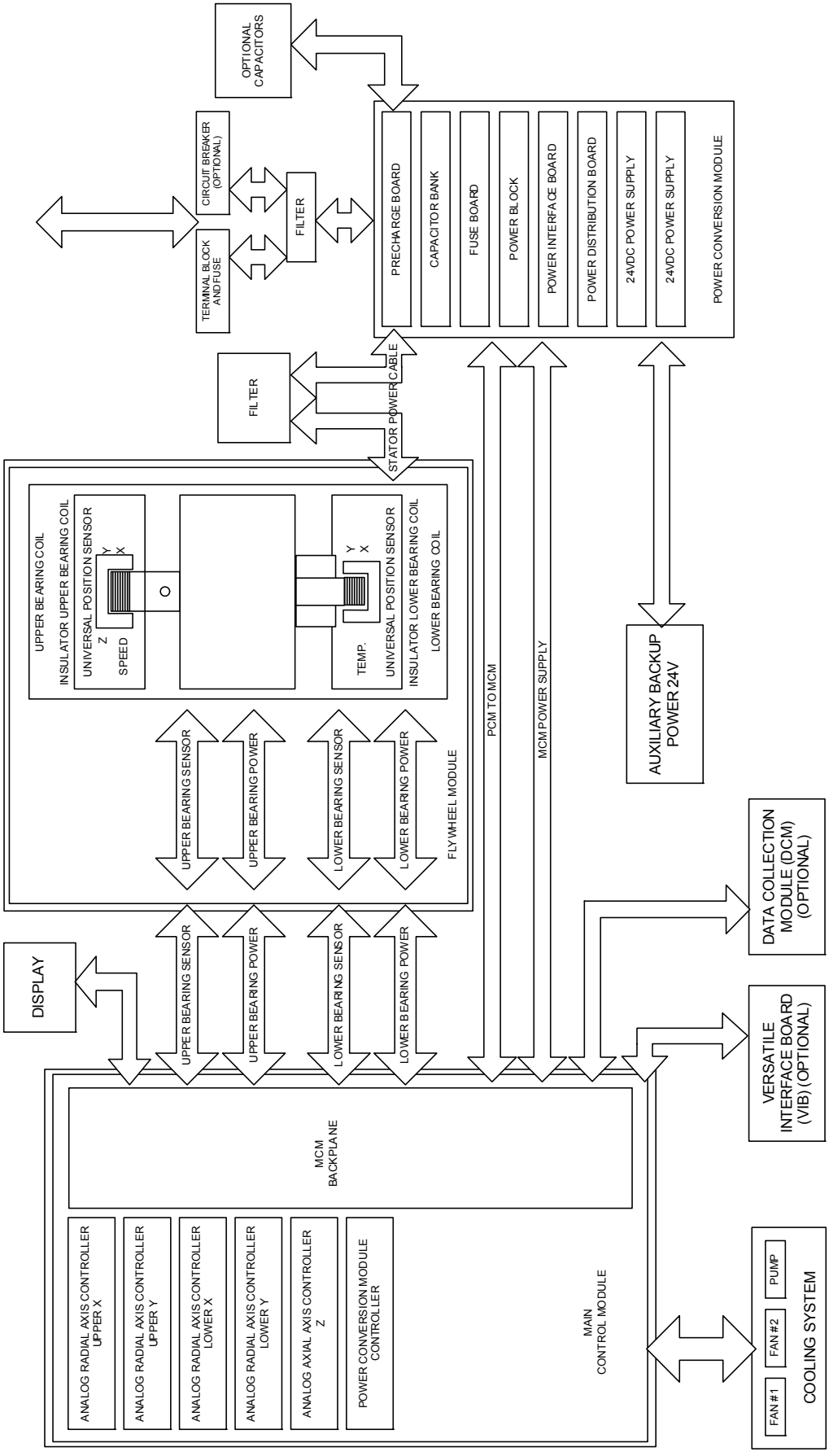


Figure 152 Power line diagram

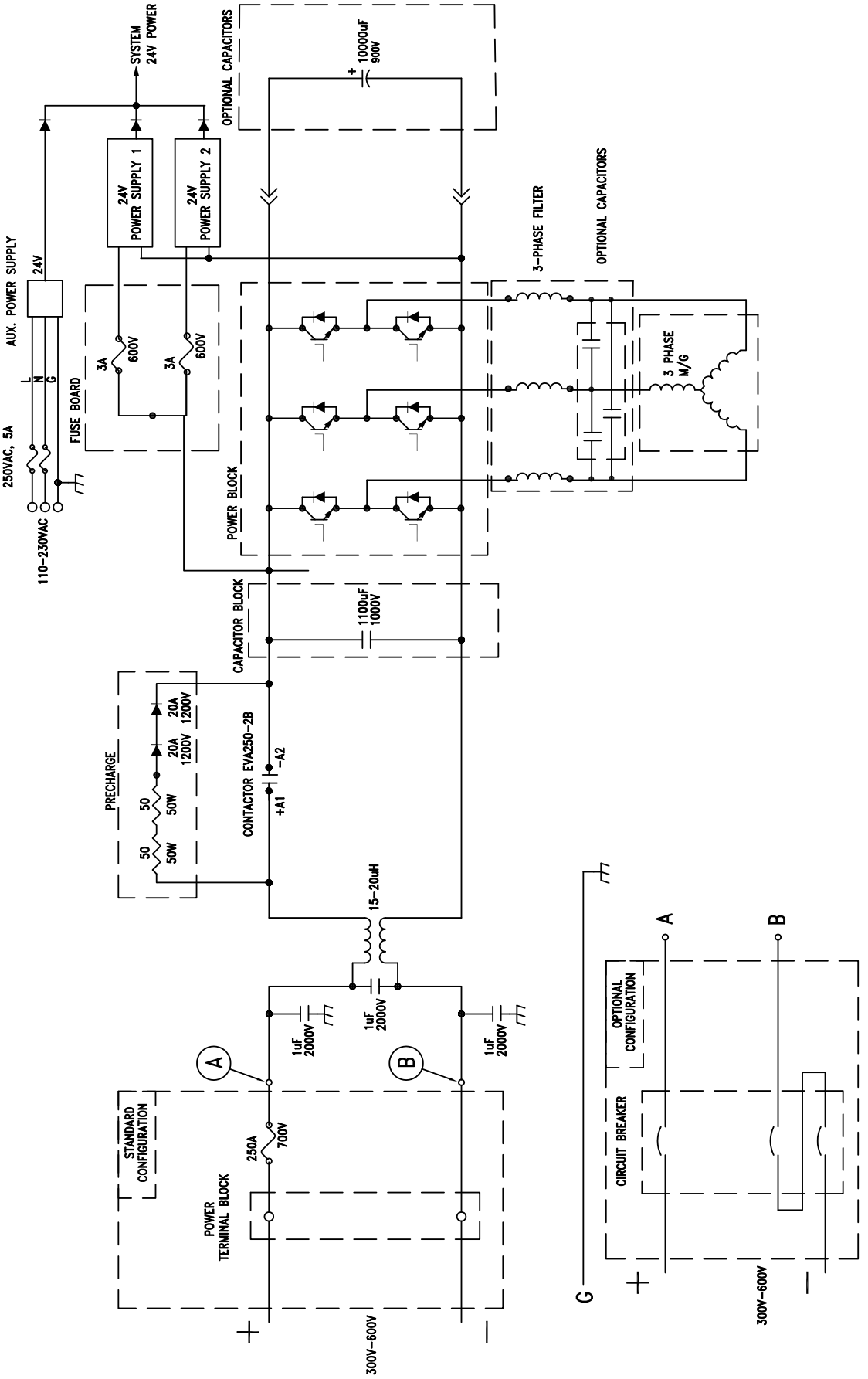


Figure 153 UPS cable entry—bottom

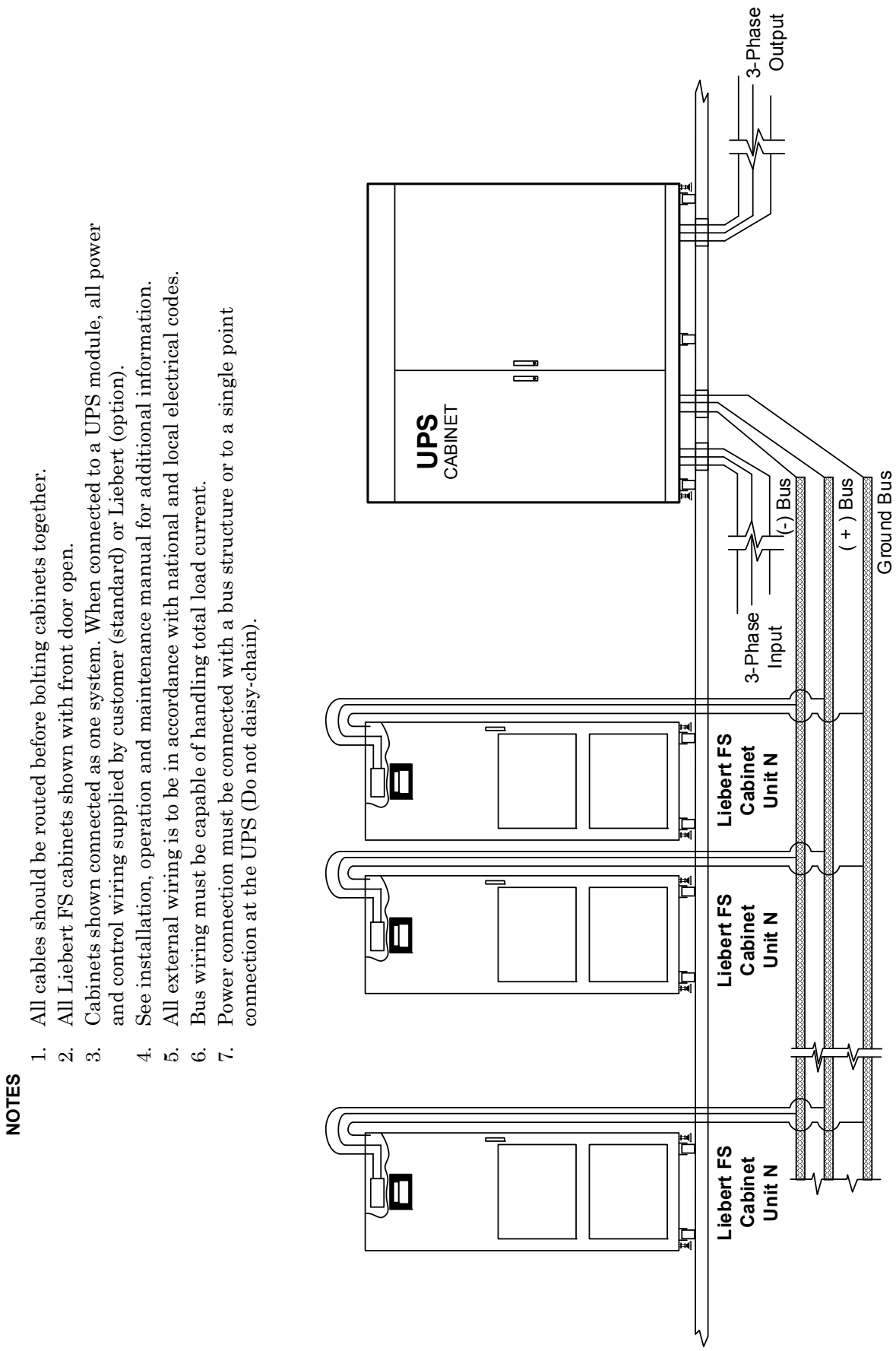
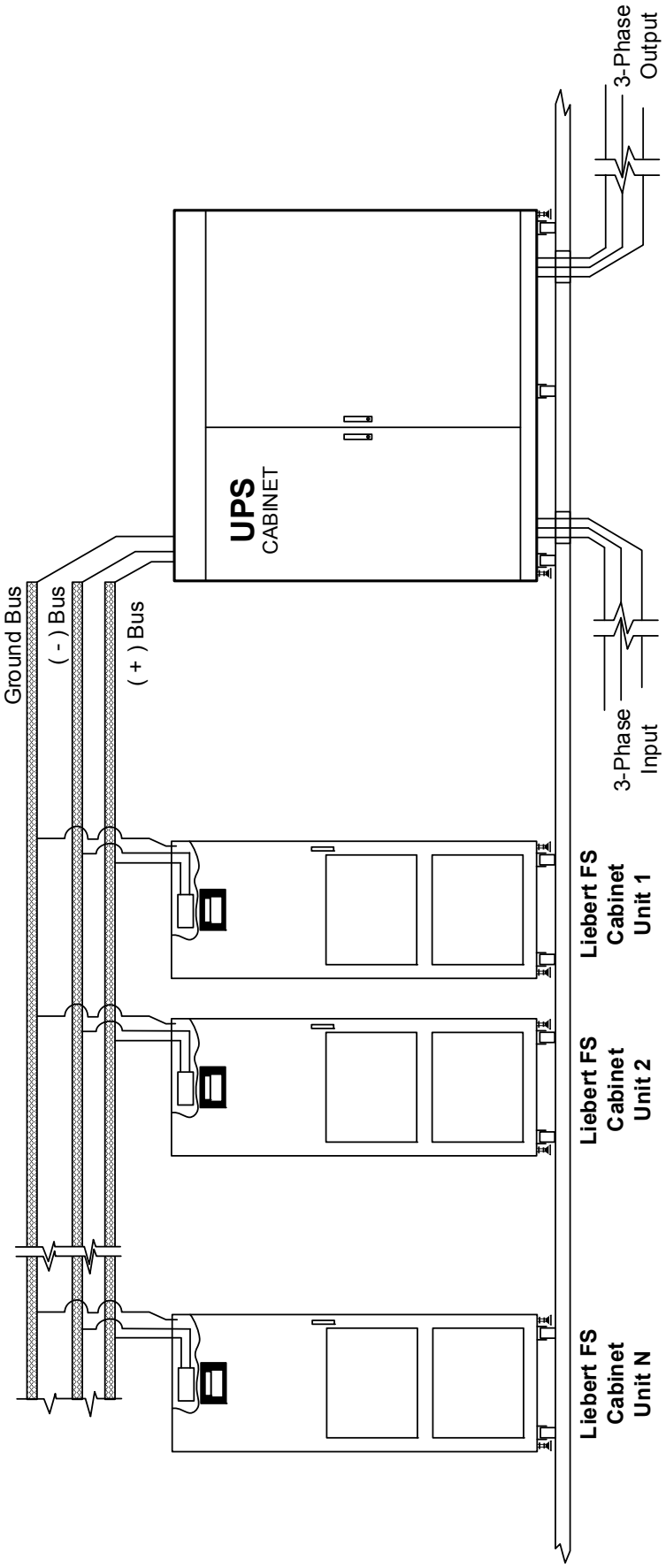


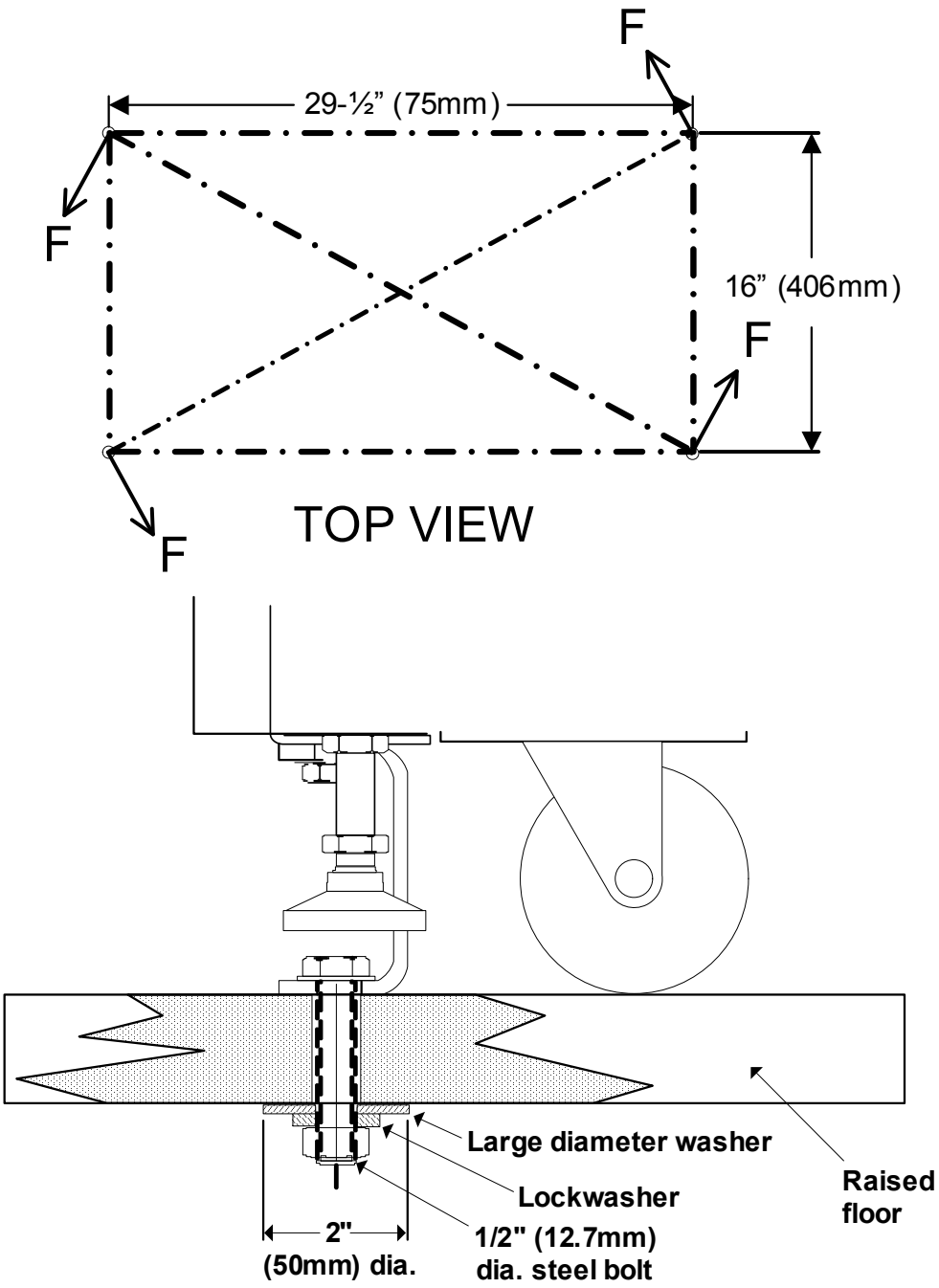
Figure 154 UPS cable entry—top



NOTES

1. All cables should be routed before bolting cabinets together.
2. All Liebert FS cabinets shown with front door open.
3. Cabinets shown connected as one system. When connected to a UPS module, all power and control wiring supplied by customer (standard) or Liebert (option).
4. See installation, operation and maintenance manual for additional information.
5. All external wiring is to be in accordance with national and local electrical codes.
6. Bus wiring must be capable of handling total load current.
7. Power connection must be connected with a bus structure or to a single point connection at the ups (Do not daisy-chain).

Figure 155 Raised floor mounting



NOTE: Combination of floor material of given thickness , plus properties of large diameter washer and fastener , should result in lateral load capability to withstand shear due to load F =1500 lb (680kg), parallel to floor.

For thicker floors that might require a bolt length longer than can fit inside mounting channel , insert bolt from below with nut above.

APPENDIX E.0 SPECIFICATIONS

Table 36 Technical specifications

INPUT, DC	
Float Voltage	350 through 600 VDC; > 520 VDC required for 200kW
Charging Current	5 through 50 Amps per Liebert FS
Rated Input Charging	350-600 VDC; > 530 VDC required for 200kW
Maximum Idling Consumption	Less than 300 W
INPUT, AC	
Control Circuit Rating	100-240VAC, 440W, 50/60Hz
OUTPUT, DC	
Nominal Power	200kW [1]
Nominal Delivered Energy	200kW for 12 seconds [1]
Maximum Delivered Energy	200kW for 12 seconds [1]
Discharge Voltage (adjustable)	350 through 600 VDC
Rated Output Discharge	350-600 VDC, 250A; > 520 VDC required for 200kW
DC Voltage Regulation	± 1% steady state
DC ripple	< 2%
Current Short Time	500A
Short Circuit Withstand Current Capacity (Circuit-breaker/fused terminal block)	20 kADC / 10 kADC
INPUT, AC (AUX)	
Auxiliary Voltage	110VAC – 230VAC (50/60Hz)
Auxiliary Power Rating	500VA
ENVIRONMENTAL	
Operating Temperature	-20°C to 50°C (-4°F to 122°F)
Startup Temperature	0°C to 50°C (32°F to 122 °F)
Non-Operating Temperature	-20°C to 80°C (-4°F to 176 °F)
Humidity	5% to 95% non-condensing
Operating Altitude	Up to 3,000 meters (9,842 feet) above sea level
Non-Operating Altitude	Up to 12,000 meters (39,370 feet) above sea level
Operating Audible Noise Level	<50 dBa at 1 meter in Ready mode; less than 65 dBa when discharging
Heat Dissipation	Less than 300W (1,025 BTU/h)
Cabinet Environmental Rating	NEMA 1 / IP 30
Pollution Degree	3 (Industrial)
PHYSICAL DATA	
Dimensions (W x D x H)	63 x 83 x 181 cm (25 x 33 x 71 in)
Footprint	0.5 m² (5.7 sq ft)
Weight	590 kg (1,300 lb)
Shipping Package Weight	660 kg (1,460 lb)
Cable Access	Top or Side Entry
STANDARDS / MARKINGS	
UL Listed	
cUL Listed	
CE Mark	

1. For discharge voltages below 520 VDC, contact Liebert (1-800-LIEBERT) or your local representative.

Appendix E.1 Ground Test Procedure

The purpose of the GTS is to confirm integrity of grounding path. This test is performed when the system is completely shutdown and isolated from all external powers. Use the checklist below.

Items Required

- Handheld Multimeter - Ohmmeter

The ground-test procedure consists of verifying the resistance between the following points (expected values are given in some instances):

- PE and PPM Box (0 Ohms)
- PE and MCM Box (0 Ohms)
- PE and outer containment (0 Ohms)
- PE and door 0 Ohms.
- PE and external capacitor box (0 Ohms)
- PE and right side of enclosure (0 Ohms)
- PE and left side of enclosure (0 Ohms)
- PE and bottom of enclosure (0 Ohms)
- PE and top of enclosure (0 Ohms)
- PE and water slide (0 Ohms)
- PE and the ground on fused disconnect
- PE and the building ground

NOTE
Connect tester cable to non-painted metal or screw for testing.

APPENDIX F.0 AUXILIARY BACKUP AC POWER SUPPLY

Appendix F.1 Overview

The Liebert FS must be operated with a backup AC power supply to protect the unit's mechanical bearings if:

- the external DC supply is lost,
- the Liebert FS has developed a fault and
- the configuration is two (and only two) flywheels arranged in a capacity configuration (i.e.: both flywheels are required to carry full load). Not applicable to a redundant configuration.

If these two events occur simultaneously, the backup power supply will power the magnetic levitation hardware to prevent the rotating group from running on the mechanical touchdown bearings.

This section details the function of the backup power supply and how it should be attached to the Liebert FS. This is supplementary information—refer to appropriate sections of the user manual for details on installation and operation.

Appendix F.2 Backup AC Power Supply Specification

Voltage: 110 to 230VAC, 500VA

Frequency: 50 to 60Hz

Note: Connection to a 480VAC supply requires a 480 to 110 transformer, available from Liebert as an option.

Appendix F.3 Recommended Backup Power Supply Configuration

If the Liebert FS is operating:	Liebert recommends:	For details, see:
In parallel with batteries	Attaching the backup AC power supply to the output of the UPS.	**Figures 156** and **157**
Without batteries	Feeding the backup AC supply from a separate, protected supply. This may be the output of another UPS or a supply from a separate feeder circuit.	**Figures 158** and **159**

Appendix F.3.1 Operating the Liebert FS+DC in Parallel With Batteries

If the Liebert FS is operating in parallel with batteries, Liebert recommends attaching the backup AC power supply to the output of the UPS, as shown in **Figures 156** and **157**.

Figure 156 A single Liebert FS+DC unit operating with a UPS in conjunction with batteries

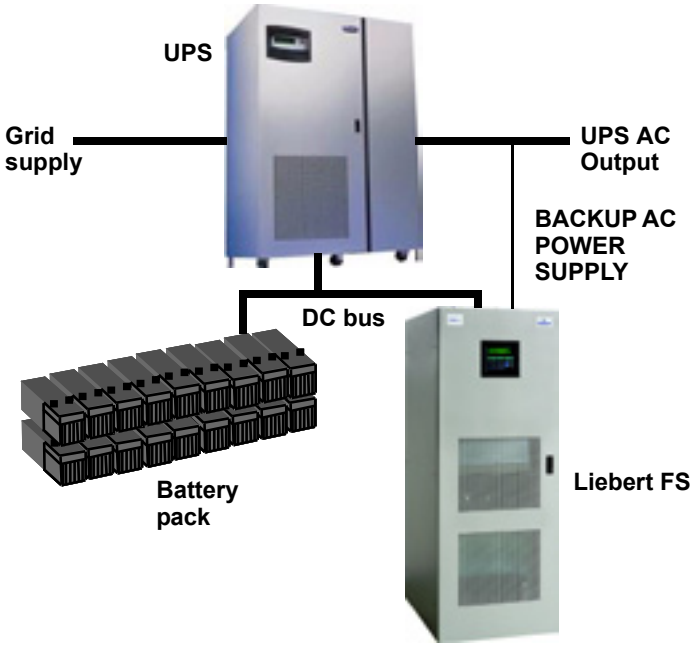
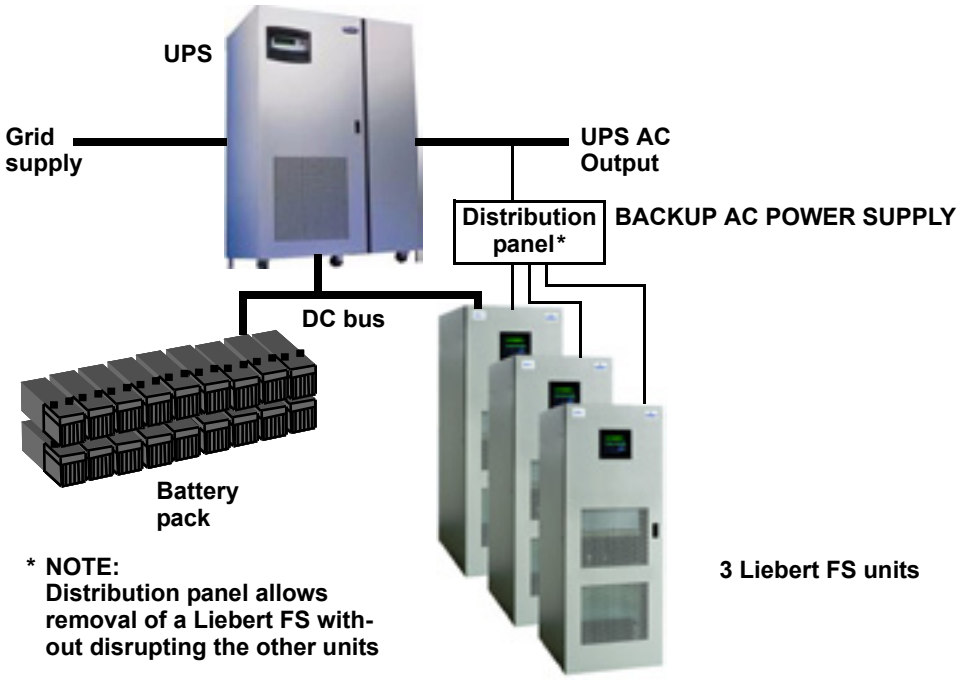


Figure 157 Multiple Liebert FS+DC units operating with a UPS in conjunction with batteries



Appendix F.3.2 Operating the Liebert FS Without Batteries

If the Liebert FS is operating without batteries, Liebert recommends feeding the backup AC power supply from a separate, protected supply. This may be the output of another UPS or a supply from a separate feeder circuit (see **Figures 158** and **159**).

Figure 158 Two Liebert FS units operating in a paralleled for capacity (not redundancy) configuration, with a UPS and without batteries attached to the DC bus

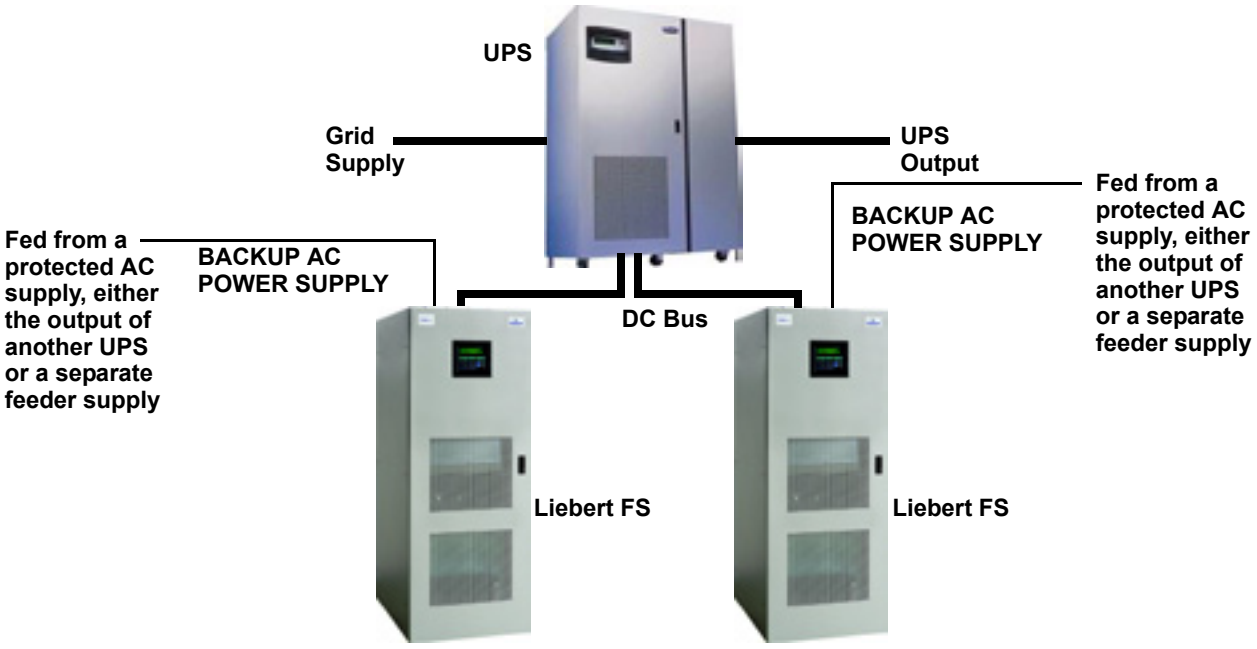
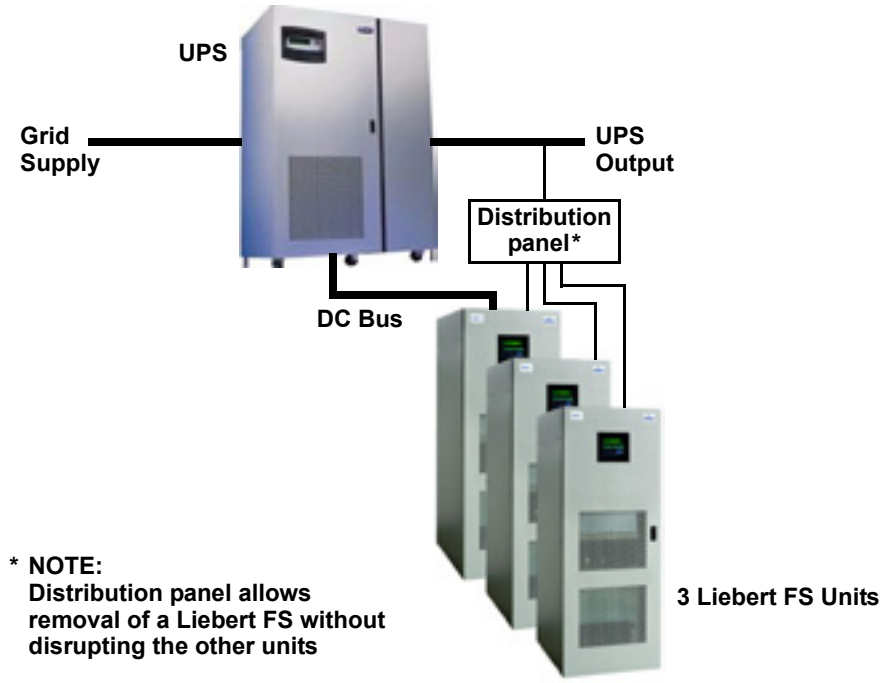


Figure 159 Multiple Liebert FS units operating with a UPS and without batteries attached to the DC bus

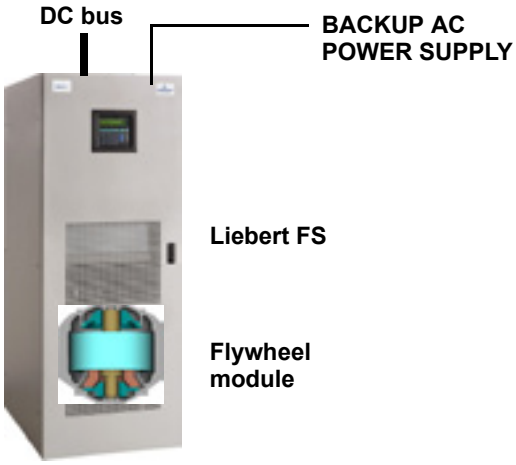


Appendix F.4 Scenarios

This section describes five scenarios that might occur.

- **Loss of backup AC supply at 0 RPM** - This causes a fault message to appear on the control panel to indicate there is a problem with the backup supply. The unit will not start until the backup supply is reinstalled.
- **Loss of backup AC supply at full speed** - This causes a warning message to appear on the control panel to indicate there is a problem with the backup supply. This warning does not affect the operation of the system.
- **Loss of external DC supply** - The Liebert FS will discharge normally until it reaches 25000 RPM. It will then change to shutdown mode and drive down to 3500 RPM, it will then coast to a stop over a number of hours.
- **Loss of external DC supply and loss of backup supply** - The Liebert FS can support the magnetic levitation hardware using energy from the flywheel. It will discharge normally until 25000 RPM, then change to shutdown mode and drive down to 3500 RPM. At this speed it can no longer support itself, and the unit will turn off. The flywheel will safely drop onto the mechanical touchdown bearings and will slowly come to a stop.
- **Loss of external DC supply, loss of backup supply and a fault message appears on the control panel** - This unlikely combination of events will cause the flywheel to drop onto the mechanical touchdown bearings without slowing to a safe rotation speed. The ceramic touchdown bearings can withstand very high speeds. However, if the flywheel were to drop onto the ceramic bearings at full speed, the bearings would last only a minute before starting to degrade. Although the system has been designed to retain the rotor as it slows, internal damage will occur during this period. The Liebert FS would require refurbishing at the factory before it could be used again.

Figure 160 Liebert FS connection



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